

09/744003

JC06 Rec'd PCT/PTO

17 JAN 2001

Practitioner's Docket No. U 013214-0

Optional Customer No. Bar Code



00140

PATENT TRADEMARK OFFICE

CHAPTER II

**TRANSMITTAL LETTER  
TO THE UNITED STATES ELECTED OFFICE (EO/US)  
(ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)**

INTERNATIONAL APPLICATION NO. CLAIMED	INTERNATIONAL FILING DATE	PRIORITY DATE
PCT/RU98/00420	DECEMBER 17, 1998	JULY 27, 1998
TITLE OF INVENTION		
METHOD AND DEVICE (VARIANTS) FOR ADJUSTING THE RESISTANCE FORCE OF A LIQUID DAMPER		
APPLICANT(S)		
1. EVGENY IVANOVICH TERNOVSKY		
2. VLADIMIR GRIGORIEVICH TUROV		

**Box PCT**  
**Assistant Commissioner for Patents**  
**Washington D.C. 20231**  
**ATTENTION: EO/US**

**CERTIFICATION UNDER 37 C.F.R. 1.10\****(Express Mail label number is mandatory.)**(Express Mail certification is optional.)*

I hereby certify that this correspondence and the documents referred to as attached therein are being deposited with the United States Postal Service on this date January 17, 2001, in an envelope as "Express Mail Post Office to Addressee," Mailing Label Number EL 728210618 US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

IBIS CARRILLO

*(type or print name of person mailing paper)*

Signature of person mailing paper

**WARNING:** Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

**\*WARNING:** Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. 1.10(b)  
"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.

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**EXPRESS MAIL LABEL**  
**NO.: EL 728210618 US**

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**NOTE:** *The completion of those filing requirements that can be made at a time later than 30 months from the priority date results from the Commissioner exercising his judgment under the authority granted under 35 USC 371(d). The filing receipt will show the actual date of receipt of the last item completing the entry into the national phase. See 37 C.F.R. §1.491 which states: "An international application enters the national state when the applicant has filed the documents and fees required by 35 USC 371(c) within the periods set forth in § 1.494 and § 1.495."*

**WARNING:** *Where the items are those which can be submitted to complete the entry of the international application into the national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. §1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing - See 37 C.F.R. §1.8.*

**NOTE:** *Documents and fees must be clearly identified as a submission to enter the national state under 35 USC 371 otherwise the submission will be considered as being made under 35 USC 111. 37 C.F.R. § 1.494(f).*

1. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. 371:
  - a. ☒ This express request to immediately begin national examination procedures (35 U.S.C. 371(f)).
  - b. ☒ The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees (37 C.F.R. § 1.492) as indicated below:

2.Fees

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
[ ]*	TOTAL CLAIMS	17 - 20 =	0	x \$ 18.00 =	\$
	INDEPENDENT CLAIMS	4 - 3 =	1	x \$ 80.00 =	80.00
	MULTIPLE DEPENDENT CLAIM(S) (if applicable) + \$270.00				
BASIC FEE**	<input type="checkbox"/> U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO: <input type="checkbox"/> and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(2) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 CFR 1.492(a)(4)) ..... \$100.00 <input type="checkbox"/> and the above requirements are not met (37 CFR 1.492(a)(1)) ..... \$690.00  <input checked="" type="checkbox"/> U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO: <input type="checkbox"/> has been paid (37 CFR 1.492(a)(2)) ..... \$710.00 <input checked="" type="checkbox"/> has not been paid (37 CFR 1.492(a)(3)) ..... \$1,000.00 <input type="checkbox"/> where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 CFR 1.492(a)(5)) ..... \$860.00				
	Total of above Calculations				=1,080.00
SMALL ENTITY	Reduction by ½ for filing by small entity, if applicable. Affidavit must be filed. (note 37 CFR 1.9, 1.27, 1.28)				- 540.00
	Subtotal				540.00
	Total National Fee				\$ 540.00
	Fee for recording the enclosed assignment document \$40.00 (37 CFR 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".				
TOTAL	Total Fees enclosed				\$ 540.00

\*See attached Preliminary Amendment Reducing the Number of Claims.

2007 REC'D PCT/IB 17 JAN 2007

- i. ☒ A check in the amount of \$540.00 to cover the above fees is enclosed.
- ii. ☐ Please charge Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_.  
A duplicate copy of this sheet is enclosed.

**\*\*WARNING:** "To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date. \* \* \* (2) the basic national fee (see § 1.492(a)). The 30-month time limit may not be extended." 37 C F R § 1.495(b).

**WARNING.** If the translation of the international application and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C F R. § 1.495(b)(2). The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1.136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40

3. ☒ A copy of the International application as filed (35 U.S.C. 371(c)(2)):

**NOTE:** Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20 At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35-36 See item 14c below.

- a. ☒ is transmitted herewith.
- b. ☐ is not required, as the application was filed with the United States Receiving Office.
- c. ☐ has been transmitted
- i. ☐ by the International Bureau.  
Date of mailing of the application (from form PCT/IB/308): \_\_\_\_\_.
- ii. ☐ by applicant on \_\_\_\_\_.  
Date

4. ☒ A translation of the International application into the English language (35 U.S.C. 371(c)(2)):

- a. ☒ is transmitted herewith.
- b. ☐ is not required as the application was filed in English.
- c. ☐ was previously transmitted by applicant on \_\_\_\_\_.  
Date
- d. ☐ will follow.

*NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. § 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under section 1.121. In many cases, filing an amendment under section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.*

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17 JAN 2001

10. ☒ An oath or declaration of the inventor (35 U.S.C. 371(c)(4)) complying with 35 U.S.C. 115
- a. ☐ was previously submitted by applicant on \_\_\_\_\_.  
Date
- b. ☒ is submitted herewith, and such oath or declaration
- i. ☐ is attached to the application.
- ii. ☒ identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. 1.70.
- c. ☐ will follow.

Other document(s) or information included:

11. ☒ An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):
- a. ☒ is transmitted herewith.
- b. ☐ has been transmitted by the International Bureau.  
Date of mailing (from form PCT/IB/308): \_\_\_\_\_.
- c. ☐ is not required, as the application was searched by the United States International Searching Authority.
- d. ☐ will be transmitted promptly upon request.
- e. ☐ has been submitted by applicant on \_\_\_\_\_.  
Date
12. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98:
- a. ☒ is transmitted herewith.  
Also transmitted herewith is/are:
- ☒ Form PTO-1449 (PTO/SB/08A and 08B).
- ☒ Copies of citations listed.
- b. ☐ will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. 371(c).
- c. ☐ was previously submitted by applicant on \_\_\_\_\_.  
Date
13. ☐ An assignment document is transmitted herewith for recording.

A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

14. ☒ Additional documents:
- a. ☒ Copy of request (PCT/RO/101) (ENGLISH & RUSSIAN)
  - b. ☒ International Publication No. WO 00/06402
    - i. ☐ Specification, claims and drawing
    - ii. ☒ Front page only
  - c. ☒ Preliminary amendment (37 C.F.R. § 1.121)
  - d. ☐ Other

COPY OF FORM PCT/IB/306: COPY OF FORM PCT/IPEA/401 (DEMAND):  
COPY OF FORM PCT/IPEA/408: COPY OF WRITTEN OPINION: COPY OF  
RESPONSE TO WRITTEN OPINION: THIRTY SIX (36) SHEETS OF  
DRAWINGS (FORMAL).

15. ☒ The above checked items are being transmitted
- a. ☒ before 30 months from any claimed priority date.
  - b. ☐ after 30 months.
16. ☐ Certain requirements under 35 U.S.C. 371 were previously submitted by the applicant on \_\_\_\_\_, namely:
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

#### AUTHORIZATION TO CHARGE ADDITIONAL FEES

**WARNING:** *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges if extra claims are authorized.*

**NOTE:** *"A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).*

**NOTE:** *"Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).*

☒ The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 12-0425.

☒ 37 C.F.R. 1.492(a)(1), (2), (3), and (4) (filing fees)

**WARNING:** *Because failure to pay the national fee within 30 months without extension (37 C.F.R. § 1.495(b)(2)) results in abandonment of the application, it would be best to always check the above box.*

☐ 37 C.F.R. 1.492(b), (c) and (d) (presentation of extra claims)

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NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action

- ☒ 37 C.F.R. 1.17 (application processing fees)  
☒ 37 C.F.R. 1.17(a)(1)-(5)(extension fees pursuant to § 1.136(a).  
☒ 37 C.F.R. 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. § 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

- ☐ 37 C.F.R. § 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).




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 SIGNATURE OF PRACTITIONER

---

 WILLIAM R. EVANS

(type or print name of practitioner)

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 LADAS & PARRY

P.O. Address

---

 26 WEST 61<sup>ST</sup> STREET

NEW YORK, NEW YORK 10023

Reg. No.: 25,858

Tel. No.: (212)708-1930

Customer No.: 00140



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JCS/1000 PCT/PTO 17 JAN 2001

**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re application of: EVGENY IVANOVICH TERNOVSKY, et al

International Application No.: PCT/RU98/00420

International Filing Date: December 17, 1998

For: METHOD AND DEVICE (VARIANTS) FOR ADJUSTING THE RESISTANCE  
FORCE OF A LIQUID DAMPER

Attorney Docket No.: U 013214-0

**Assistant Commissioner for Patents**  
**Washington, D.C. 20231**

Sir:

**PRELIMINARY AMENDMENT**

Please amend the above identified application as follows:

**IN THE CLAIMS**

Claim 12, line 1, delete "or claim 11"

Claim 17, line 1, delete "or claim 16"

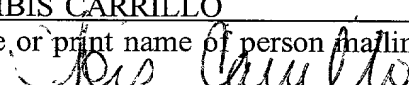
Respectfully submitted,

  
\_\_\_\_\_  
WILLIAM R. EVANS  
LADAS & PARRY  
26 WEST 61ST STREET  
NEW YORK, NEW YORK 10023  
REG.NO.25858(212)708-1930

---

**CERTIFICATE UNDER 37 1.10**

I hereby certify that this paper is being deposited with the United States Postal Service on this date JANUARY 17, 2001 in an envelope as "EXPRESS MAIL POST OFFICE TO ADDRESSEE" Mailing Label Number EL 728210618 US addressed to the: Commissioner of Patents and Trademarks, Washington, D.C. 20231

IBIS CARRILLO  
(Type or print name of person mailing paper)  
  
\_\_\_\_\_  
(Signature of person mailing paper)

**NOTE:** Each paper or fee referred to as enclosed herein has the number of the "EXPRESS MAIL" mailing label place thereon prior to mailing 37 CFR 1.16(b).

Practitioner's Docket No. U 013214-0

**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

☒ In re application of: Evgeny Ivanovich Ternovsky et al.

Application No.:

Group No.:

Filed:

Examiner:

For: Method and Device (Variants) for Adjusting the Resistance  
Force of a Liquid Damper

☐ \*Patent No.:

Issue Date:

*\*NOTE: Insert name(s) of inventor(s) and title also for patent Where statement is with respect to a maintenance fee payment, also insert application number and filing date, and add Box M. Fee to address.*

**STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(c-f) and 1.27(b-d))**

With respect to the invention described in

☒ the specification filed herewith.

☐ application no. \_\_\_\_\_, filed \_\_\_\_\_.

☐ patent no. \_\_\_\_\_ issued \_\_\_\_\_.

**I. IDENTIFICATION AND RIGHTS AS A SMALL ENTITY**

I hereby state that I am

*(complete either (a), (b), (c) or (d) below)*

**(a) Independent Inventor**

☒ a below named independent inventor, and that I qualify as an independent inventor, as defined in 37 CFR 1.9(c), for purposes of paying reduced fees under Sections 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office.

**(b) Noninventor Supporting a Claim by Another**

☐ making this statement to support a claim by

for a small entity status for purposes of paying reduced fees under Sections 41(a) and (b) of Title 35, United States Code. I hereby state that I would qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under Sections 41(a) and (b) of Title 35, United States Code, if I had made the above identified invention.

**(c) Small Business Concern**

☐ the owner of the small business concern identified below:

☐ an official of the small business concern empowered to act on behalf of the concern identified below:

Name of Concern  
Address of Concern

\_\_\_\_\_ and  
that the above identified small business concern qualifies as a small business concern, as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Sections 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

(d) Non-Profit Organization

☐ an official empowered to act on behalf of the nonprofit organization identified below:

Name of Organization  
Address of Organization

TYPE OF ORGANIZATION

- ☐ University or Other Institution of Higher Education
- ☐ Tax Exempt Under Internal Revenue Service Code (26 USC 501(a) and 501(c) (3))
- ☐ Nonprofit Scientific or Educational Under Statute of State of the United States of America  
(Name of State \_\_\_\_\_)  
(Citation of Statute \_\_\_\_\_)
- ☐ Would Qualify as Tax Exempt Under Internal Revenue Service Code (26 USC 501(a) and 501(c) (3)), if Located in the United States of America
- ☐ Would Qualify as Nonprofit Scientific or Educational Under Statute of State of the United States of America, if Located in the United States of America  
(Name of State \_\_\_\_\_)  
(Citation of Statute \_\_\_\_\_)

and that the nonprofit organization identified above qualifies as a nonprofit organization, as defined in 37 CFR 1.9(e), for purposes of paying reduced fees under Sections 41(a) and (b) of Title 35, United States Code.

**II. OWNERSHIP OF INVENTION BY DECLARANT**

I hereby state that rights under contract or law remain with and/or have been conveyed to the above identified

☐ person ☐ concern ☐ organization  
(item (a) or (b) above) (item (c) above) (item (d) above)

EXCEPT, that if the rights held are not exclusive, each individual, concern or organization having rights to the invention is listed below\* and no rights to the invention are held (1) by any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, (2) any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or (3) a nonprofit organization under 37 CFR 1.9(e).

- ☐ no such person, concern, or organization  
☐ person, concerns or organizations listed below\*

*\*NOTE: Separate statements are required from each named person, concern or organization having rights to the invention as to their status as small entities. (37 CFR 1.27)*

Full Name

Address

☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

Full Name

Address

☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

### III. ACKNOWLEDGEMENT OF DUTY TO NOTIFY PTO OF STATUS CHANGE

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

### IV. DECLARATION

*(check the following item, if desired)*

**NOTE:** *The following verification statement need not be made in accordance with the rules published on October 10, 1997, 62 Fed. Reg. 52131, effective December 1, 1997.*

**NOTE:** *"The presentation to the Office (whether by signing, filing, submitting, or later advocating) of any paper by a party, whether a practitioner or non-practitioner, constitutes a certification under § 10.18(b) of this chapter. Violations of § 10.18(b)(2) of this chapter by a party, whether a practitioner or non-practitioner, may result in the imposition of sanctions under § 10.18(c) of this chapter. Any practitioner violating § 10.18(b) may also be subject to disciplinary action. See §§ 10.18(d) and 10.23(c)(15)." 37 CFR 1.4(d)(2).*

- ☐ I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

**V. SIGNATURES**

*(complete only (e) or (f) below)*

**(e)**

NOTE: All inventors must sign the statement.

Name of Inventor **EVGENY IVANOVICH TERNOVSKY**

*Евгений Иванович Терновский*

Date: January 12, 2001

**Signature of Inventor**

Name of Inventor **VLADIMIR GRIGORIEVICH TUROV**

*Владимир Григорьевич Туров*

Date: January 12, 2001

**Signature of Inventor**

Name of Inventor

Date: \_\_\_\_\_

**Signature of Inventor**

*(add lines for any additional inventors who must sign)*

or

**(f)**

NOTE: The title of the person signing on behalf of a concern or nonprofit organization should be specified.

Name of Person Signing

Title of Person

*(if signing on behalf of a concern or non-profit organization)*

Address of Person Signing

SIGNATURE \_\_\_\_\_

DATE

## SPECIFICATION OF THE INVENTION

## Title of the Invention

5 Method and device (variants) for adjusting the resistance force of a liquid damper.

## Field of the Invention

10 The present invention relates to the field of transport engineering, and more exactly to a method for adjusting the resistance force of a liquid damper and to a device for carrying out this method. The present invention can be used to the greatest advantage in suspensions of wheeled vehicles. Furthermore, it may be used in the suspensions of snowmobiles or vehicles on tracks, and also in the undercarriage of flying vehicles.

## 15 Background Art

20 A liquid damper is used to effectively prevent the development of resonance conditions during forced oscillations of the sprung and unsprung masses and to ensure the effective damping of oscillations of those masses in the suspension of a vehicle. The damper converts kinetic energy of the sprung mass and the unsprung mass, which they acquire during vertical oscillations, and the excess of potential energy, which is stored in an elastic element of the suspension, into heat energy and dissipates it into the environment. The cavity of the damper is divided into at least two chambers. The  
25 volume of one of those chambers, the compression (expansion) chamber is reduced, while the volume of the other, the expansion (compression) chamber increases due to the movement of a piston separating those chambers when the piston accomplishes forward (return) movement in the working cylinder of the damper. As a result of the change in the volume, a pressure is created in the compression (expansion) chamber, which is  
30 excessive in respect to the other cavities of the damper. Due to the effect of the excessive pressure, the working liquid flows through a compression (expansion) channel which couples the compression (expansion) chamber to the other cavities of the damper during the forward (return) movement of the piston. The action of the excessive pressure of the working liquid on the parts of the damper via which the damper interacts with the sprung

mass and the unsprung mass of the vehicle creates a resistance force of the damper. Mechanical energy, spent on moving the piston, is consumed to accomplish the work on overcoming the resistance force of the damper. The absolute value of the resistance force of the damper is in inverse proportion to the flow cross section of the compression (expansion) channel and in direct proportion to the rate at which the volume of the damper cavities changes and, accordingly, to the speed at which the piston moves. The dependence of the resistance force of the damper on the speed of movement of its piston is called the characteristic of damper resistance. The characteristic of damper resistance is called hard where the absolute value of the resistance force in the working range of piston movement speeds is large. The characteristic of damper resistance is called soft where the absolute value of the resistance force in the working range of piston movement speeds is small.

In order to reduce the amplitude of oscillations of the sprung mass and to reduce the force acting on the sprung mass, it is necessary to increase the absolute value of the resistance force of the damper during the damping of the oscillations of the sprung mass and during the action of external excitations (unevenness of a road) on the vehicle, the frequency of which approximately coincides with the cyclic frequency of free oscillations of the sprung mass itself.

In order to reduce the amplitude of oscillations of the sprung mass and to reduce the force acting on the sprung mass, it is necessary to reduce the absolute value of the resistance force of the damper while there are external excitations acting on the vehicle, the repetition frequency of which is greater than the cyclic frequency of free oscillations of the sprung mass.

Fulfillment of the aforesaid requirements is effected by adjusting the resistance force created by the damper.

A method of adjusting the resistance force of a liquid damper is known from laid-open German application DE 41 39 746 A1. This method is based on the difference in the speeds of movement of the damper piston and, accordingly, the differences in the values of the excessive pressure of the working liquid formed in the compression (expansion) chamber, which are characteristic for high-frequency forced oscillations of the sprung mass and free oscillations of the sprung mass. The method consists of changing the flow cross section of the compression (expansion) channel in direct proportion to the value of the excessive pressure in the compression (expansion) chamber. Wherein, the current value of the flow cross section of the compression (expansion)

channel is formed by the cross section of a constant restrictor, which constantly couples the compression (expansion) chamber to the other cavities of the damper, and the current cross section of the slit of the compression (expansion) valve. If there is no constant restrictor, the current value of the cross section of the compression (expansion) channel is equal to the current cross section of the slit of the compression (expansion) valve. A change in the cross section of the compression (expansion) channel is attained in that the force with which the excessive pressure acts on a movable element of the compression (expansion) valve, the current position of which determines the current linear size of the valve slit, is balanced by an oppositely directed elastic force of an elastic element of that valve. The movable element of the valve may be any structural element which closes the outlet aperture of the channel supplying the working liquid. Such an element may be, for example, a plate, a ball or a plunger.

A device for carrying out the described method is also known from laid-open German patent DE 41 39 746 A1. This device is a liquid damper having compression and expansion chambers which are formed as a result of dividing the cavity of the damper with a piston which is secured to the end of a rod. The piston consists of at least two elements. A compression (expansion) channel consists of a constant restrictor and a compression (expansion) valve. The constant restrictor is positioned in the body of the piston and ensures constant coupling of the compression and expansion chambers. There may be no constant restrictor. In that case the compression (expansion) channel only has a compression (expansion) valve. The compression (expansion) valve includes:

a) a supply channel which is made in the body of the piston and has at least one inlet aperture positioned from the side of the compression (expansion) chamber, and at least one outlet aperture positioned from the side of the expansion (compression) chamber;

b) a plate which closes the outlet aperture of the supply channel from the side of the expansion (compression) chamber;

c) an elastic element, the action of the elastic force of which on the plate is directed towards the piston;

d) a support for the elastic element, which fixes the position of the end of the elastic element opposite to the piston along the longitudinal axis of the damper relative to the seat of the valve.



The plate of the compression (expansion) valve and its elastic element may be structurally combined in one element in which an elastic force is produced when it is bent relative to the plane of conjugation of that element with the valve seat.

When there is an excessive pressure of the working liquid in the compression (expansion) chamber, the effective force of which on the plate of the compression (expansion) valve is less than the elastic force of the elastic element of that valve, which acts on the plate in the absence of excessive pressure in the compression (expansion) chamber, the outlet aperture of the supply channel of the compression (expansion) valve is closed by the plate and the flow cross section of the compression (expansion) channel is equal to the cross section of the constant restrictor or, if there is no constant restrictor, is absent. When the excessive pressure increases, the plate opens the outlet aperture of the supply channel of the compression (expansion) valve and the flow cross section of the compression (expansion) channel increases in direct proportion to the value of the excessive pressure, right up to the maximum value which is equal to the sum of the cross section of the constant restrictor and the cross section of the supply channel of the compression (expansion) valve or is equal to the cross section of the supply channel of the compression (expansion) valve if there is no constant restrictor.

The known method does not make it possible to a sufficient degree to adjust the resistance force of the damper because of the absence of a difference between piston stroke speeds in the case of large amplitude oscillations at a frequency approximately equal to the natural cyclic frequency of free oscillations of the sprung mass and, in the case of small and average amplitude oscillations at a frequency which is several times higher than the natural cyclic frequency of free oscillations of the sprung mass.

Therefore, in order to substantially reduce the amplitude of the oscillations of the sprung mass and to reduce the force acting on the sprung mass when the vehicle is subjected to the action of external excitations, the repetition frequency of which approximately coincides with the natural cyclic frequency of the free oscillations of the sprung mass, the damper should have a sufficiently hard resistance characteristic. However, in the second case, such a damper causes an increase in the amplitude of oscillations of the sprung mass and an increase in the force acting thereon, as compared with a damper which has a soft resistance characteristic.

In order to reduce the amplitude of oscillations of the sprung mass and to reduce the force acting on the sprung mass when the vehicle is subjected to the action of external excitations, the repetition frequency of which is several times higher than the natural

cyclic frequency of the free oscillations of the sprung mass, the damper should have a sufficiently soft resistance characteristic. However, in the first case, such a damper dissipates an insufficient amount of energy and causes an increase in the amplitude of oscillations of the sprung mass and an increase of the force acting thereon, as compared with a damper which has a hard resistance characteristic.

### Disclosure of the Invention

The present invention solves the problem of automatically changing the resistance characteristic of a damper in relation to the amplitude of an external excitation (automatic adaptation of the damper to the character of a road surface), which makes it possible to attain:

a) a reduction of the force acting on the sprung mass and a reduction of the amplitude of its oscillations during the time of action of the external excitations on the vehicle, the repetition frequency of which is at least two times higher than the natural cyclic frequency of free oscillations of the sprung mass, as compared with a damper in which a known method of adjusting the resistance force is used and which has a hard resistance characteristic;

b) a reduction of the force acting on the sprung mass and a reduction of the amplitude of its oscillations during the time of action of the external excitations on the vehicle, the repetition frequency of which approximately coincides with the natural cyclic frequency of the free oscillations of the sprung mass, as compared with a damper in which a known method of adjusting the resistance force is known and which has a soft resistance characteristic.

The technical result obtained by use of each of the variants of the present invention is expressed by:

a) a reduction of the force acting on the sprung mass and a reduction of the amplitude of its oscillations during the time of action of the external excitations on the vehicle, the repetition frequency of which is at least two times higher than the natural cyclic frequency of free oscillations of the sprung mass, as compared with a damper in which a known method of adjusting the resistance force is used and which has a hard resistance characteristic;

b) a reduction of the force acting on the sprung mass and a reduction of the amplitude of its oscillations during the time of action of the external excitations on the

vehicle, the repetition frequency of which approximately coincides with the natural cyclic frequency of the free oscillations of the sprung mass, as compared with a damper in which a known method of adjusting the resistance force is known and which has a soft resistance characteristic;

- 5 c) a reduction of the force acting on the sprung mass and a reduction of the amplitude of its oscillations when a single external excitation is exerted on the vehicle.

The proposed method for adjusting the resistance force of a liquid damper comprises the adjustment which is carried out in the known method and additional adjustment depending on the current position of the piston in the working cylinder of the damper, due to which the damper automatically adapts to the character of the road surface.

The proposed method consists in that, as in the known method, the flow cross section of the compression (expansion) channel is changed in direct proportion to the value of the excessive pressure in the compression (expansion) chamber. Correspondence of the cross section size of the compression (expansion) channel to the current value of the excessive pressure of the working liquid in the compression (expansion) chamber is provided in that the force with which the excessive pressure acts on a movable element of a compression (expansion) valve, the current position of which determines the current linear size of the valve slit, is balanced by an oppositely directed elastic force of an elastic element of that valve.

The proposed method has the following distinctions over the known method. In order to carry out additional adjustment, a controlled displacement of at least one part of the damper is provided, the position of this part relative to another part of the damper affecting the magnitude of the flow cross section of the compression (expansion) channel. The forward (return) movement of the piston in the working cylinder of the damper is converted into a change in the position of those parts relative to one another, and each such position of the parts is set in accordance with the size of the flow cross section of the compression (expansion) channel, which corresponds to a constant value of the excessive pressure.

The proposed method has seven main variants indicated below and also derivatives of the variants, which are different combinations of the main variants.

Variant 1. Forward (return) movement of the piston is converted into a turn of a damper part closing a constant restrictor relative to a damper part in which an aperture of the constant restrictor is made. Each angle of turn of these parts relative to each other

sets in accordance therewith the degree of closure of the aperture of the constant restrictor by the movable part and accordingly, the flow cross section of the constant restrictor.

Variant 2. Forward (return) movement of the piston is converted into linear displacement of the damper part closing the constant restrictor relative to the part of the damper in which an aperture of the constant restrictor is made. Each position of these parts relative to each other sets in accordance therewith the degree of closure of the aperture of the constant restrictor by the movable part and accordingly, the flow cross section of the constant restrictor.

Variant 3. Forward (return) movement of the piston is converted into a turn of a damper part closing a supply channel of a compression (expansion) valve relative to a damper part in which an aperture of that supply channel is made. Each angle of turn of these parts relative to each other sets in accordance therewith the degree of closure of the aperture of the supply channel by the movable part and accordingly, the flow cross section of the constant restrictor.

Variant 4. Forward (return) movement of the piston is converted into linear displacement of the damper part closing a supply channel of a compression (expansion) valve relative to a damper part in which an aperture of that supply channel is made. Each position of these parts relative to each other sets in accordance therewith the degree of closure of the aperture of the supply channel by the movable part and accordingly the flow cross section of the supply channel of the compression (expansion) valve.

Variant 5. Forward (return) movement of a piston is converted into a turn of a damper part relative to another damper part, which together with the first part forms a seat of a compression (expansion) valve. Each angle of turn of those parts relative to each other sets in accordance therewith a value of the area limited by the seat of the compression (expansion) valve and the force with which the excessive pressure of the working liquid in the compression (expansion) chamber acts on a movable element of the compression (expansion) valve, the current position of which determines the current linear size of a slit of that valve, and consequently sets in accordance therewith the value of the cross section of the slit of the compression (expansion) valve corresponding to a constant value of the excessive pressure of the working liquid in the compression (expansion) chamber.

Variant 6. Forward (return) movement of a piston is converted into linear displacement of a damper part relative to another damper part which together with the

first part forms a seat of a compression (expansion) valve. Each position of these parts relative to each other sets in accordance therewith the value of the area limited by the seat of the compression (expansion) valve and the force with which the excessive pressure of the working liquid in the compression (expansion) chamber acts on a movable element of the compression (expansion) valve, the current position of which determines the current linear size of the slit of that valve, and consequently sets in accordance therewith the value of the cross section of the slit of the compression (expansion) valve, corresponding to a constant value of the excessive pressure of the working liquid in the compression (expansion) chamber.

Variant 7. Forward (return) movement of the piston is converted into linear displacement of a support of an elastic element of the compression (expansion) valve relative to a seat of that valve. Each position of the support relative to the seat sets in accordance therewith the value of the elastic deformation of an elastic element of the compression (expansion) valve and the elastic force with which the elastic element acts on a movable element of the valve, the current position of which determines the current linear size of the slit of that valve. Thus, each position of the support relative to the seat of the compression (expansion) valve sets in accordance therewith the value of the cross section of the slit of that valve, corresponding to a constant value of the excessive pressure of the working liquid in the compression (expansion) chamber.

A device for carrying out the first and third main variants of the proposed method is a liquid damper which has a compression chamber and an expansion chamber, which are formed as a result of dividing the damper cavity with a piston. The piston is secured to an end of a rod and consists of at least two elements. During the forward (return) movement of the piston in the working cylinder of the damper, the flow of the working liquid from the compression (expansion) chamber into the expansion (compression) chamber goes through a compression (expansion) channel which includes at least a compression (expansion) valve. The compression (expansion) valve has:

a) a supply channel which is made in the body of the piston and has at least one inlet aperture, which is positioned from the side of the compression (expansion) chamber, and at least one outlet aperture, which is positioned at the side of the expansion (compression) chamber;

b) a plate which closes the outlet aperture of the supply channel from the side of the expansion (compression) chamber;

c) an elastic element, the action of the elastic force of which on the plate is directed towards the piston.

The proposed device has the following distinctions over the known device which is designed to carry out the known method.

At least two elements of the piston have the possibility of separately turning about the longitudinal axis of the working cylinder of the damper. The device has a cylindrical structural element which is coaxial with the rod of the damper. At least two longitudinal guides are made on that section of the surface of that element which coincides with the stroke of the piston. At least one of those guides is made helical. At each point of the piston stroke, the central angle between those guides sets the angle of turn of the first element of the piston relative to the second element of the piston. At least one structural element is positioned on the side surface of both the first and the second elements of the piston. By means of this structural element, the first element of the piston interacts with one of the guides of the cylindrical structural element, while the second element of the piston interacts with another guide of the cylindrical structural element. Any element which transmits a force occurring at the heel of its contact with a guide to an element of the piston may be such a structural element. This structural element may be made, for example, in the form of a protrusion on a side surface of an element of the piston or in the form of a ball having a seat on a side surface of an element of the piston. At least two apertures, one of which is made in the first element of the piston, while the other is made in the second element of the piston, form a through channel in the body of the piston. With the piston in the position corresponding to the minimum flow cross section of the compression (expansion) channel with the compression (expansion) valve completely open, the flow cross section of the through channel, formed by the apertures of the first and second elements of the piston, at the most is less than the flow cross section of that through channel in the piston position corresponding to the maximum flow cross section of the compression (expansion) channel with the compression (expansion) valve completely open.

The proposed device may have two variants, which are distinctive in that:

a) the guides with which the elements of the piston interact are made on the inner surface of the working cylinder of the damper;

b) the rod of the damper is made hollow, the guides with which the elements of the piston interact are made on the external surface of a pin which is secured on the

bottom of the compression chamber and which moves into the cavity of the rod during forward movement of the piston.

The device for carrying out the third and fifth main variants of the proposed method has the following distinctions over the device designed for carrying out the first and third main variants of the proposed method.

The piston of the damper has a third element which is similar to the first two elements and is positioned at the side of the compression chamber or the expansion chamber. An additional guide, similar to the other guides, is made on the surface of the cylindrical structural element. The third element of the piston interacts with the additional guide. At each point of the piston stroke, the central angle between that guide and the guide interacting with the element of the piston which is positioned in the middle of the piston sets the angle of turn of those elements of the piston relative to one another. The supply channel of the compression (expansion) valve is formed by at least three apertures. Each of these apertures is made in one of the three elements. All of these apertures have the shape of a sector of a ring with the center on the longitudinal axis of the working cylinder of the damper and have identical external and internal radii. The radial side of the aperture of the supply channel of the compression (expansion) valve, made in the element of the piston which is positioned in the middle of the piston, which approaches the radial side of the outlet aperture of the supply channel during the reduction of the flow cross section of that same supply channel, is limited by a protrusion on the element of the piston. This protrusion has the shape of a sector of a ring with a center on the longitudinal axis of the working cylinder of the damper and extends through the outlet aperture of the supply channel of the compression (expansion) valve. This protrusion, together with the piston element surface which limits the outlet aperture from the side of the expansion (compression) chamber, forms a seat of the compression (expansion) valve. At each point of the piston stroke, the flow cross section formed by the inlet aperture of the supply channel of the compression (expansion) valve and the aperture of that same supply channel, which is made in the piston element that is positioned in the middle of the piston, is at least equal to the flow cross section formed by the latter aperture and the outlet aperture of the supply channel of the compression (expansion) valve.

A device for carrying out the second and fourth main variants of the proposed method is a liquid damper which has a compression chamber and an expansion chamber, which are formed as a result of dividing the damper cavity with a piston. The piston is

secured to an end of a rod and consists of at least two elements. During the forward (return) movement of the piston in the working cylinder of the damper, the flow of the working liquid from the compression (expansion) chamber into the expansion (compression) chamber goes through a compression (expansion) channel which includes at least a compression (expansion) valve. The compression (expansion) valve has:

a) a supply channel which is made in the body of the piston and has at least one inlet aperture, which is positioned at the side of the compression (expansion) chamber, and at least one outlet aperture, which is positioned at the side of the expansion (compression) chamber;

b) a plate which closes the outlet aperture of the supply channel from the side of the expansion (compression) chamber;

c) an elastic element, the action of the elastic force of which on the plate is directed towards the piston.

The proposed device has the following distinctions over the known device designed to carry out the known method.

At least one through aperture in the piston is closed by a movable gate. The device has a longitudinal structural element. At least one longitudinal guide is made on a surface section of that structural element, which at least coincides with the stroke of the piston. The movable gate is pressed against the guide by an elastic element. The transverse profile of that guide sets in each point of the piston stroke a position of the movable gate relative to the aperture being closed thereby. In the position of the piston corresponding to the minimum flow cross section of the compression (expansion) channel with the compression (expansion) valve completely open, the flow cross section of the channel formed by the movable gate and the aperture being closed therewith is, at the most, less than the flow cross section of that same channel in the piston position corresponding to the maximum flow cross section of the compression (expansion) channel with the compression (expansion) valve completely open.

The proposed device may have two variants which are distinguished in that:

a) the guide with which the movable gate interacts is made on the inner surface of the working cylinder of the damper;

b) the rod of the damper is made hollow, the guide with which the movable gate interacts is made on the external surface of a pin which is secured on the bottom of the compression chamber and which during the forward movement of the piston moves into the cavity of the rod.



The device for carrying out the fourth and sixth main variants of the proposed method has the following distinctions over the device designed for carrying out the second and fourth main variants of the proposed method.

The aperture closed by the movable gate forms a supply channel of the compression (expansion) valve. The size of that aperture, which is perpendicular to the direction of movement of the gate, is constant. The movable gate has a protrusion which is perpendicular to the direction of its movement. This protrusion passes through the aperture to be closed by the gate and together with the piston surface, which limits that aperture from the side of the expansion (compression) chamber, forms a seat of the compression (expansion) valve.

The device for carrying out the seventh main variant of the proposed method is a liquid damper which has a compression chamber and an expansion chamber which are formed as a result of dividing the cavity of the damper with a piston. The piston is secured to an end of a rod. During forward (return) movement of the piston in the working cylinder of the damper, the flow of the working liquid from the compression (expansion) chamber into the expansion (compression) chamber takes place through a compression (expansion) channel which includes at least a compression (expansion) valve. The compression (expansion) valve has:

- a) a supply channel which is made in the body of the piston and has at least one inlet aperture positioned at the side of the compression (expansion) chamber and at least one outlet aperture positioned at the side of the expansion (compression) chamber;
- b) a plate which closes the outlet aperture of the supply channel at the side of the expansion (compression) chamber;
- c) an elastic element, the elastic deformation of which occurs along the longitudinal axis of the working cylinder of the damper;
- d) a support for the elastic element, which support fixes the position of the end of the elastic element opposite the piston relative to the seat of the valve.

The proposed device has the following distinctions over the known device designed to carry out the known method.

The piston of the damper and the support of the elastic element of the compression (expansion) valve have the possibility of separately turning about the longitudinal axis of the working cylinder of the damper. At least two longitudinal guides are made on the inner surface of the working cylinder of the damper, on the section coinciding with the stroke of the piston. At least one of these guides is made helical. In each point of the

piston stroke the central angle between those guides sets the angle of turn of the support of the elastic element of the compression (expansion) valve relative to the piston. A structural element, via which the piston interacts with one of the guides, is positioned on the side surface of the piston facing the inner surface of the working cylinder of the damper. A structural element, via which the support of the elastic element of the compression (expansion) valve interacts with another guide, is positioned on the side surface of the support, which faces the inner surface of the working cylinder of the damper. The support of the elastic element of the compression (expansion) valve has the possibility of moving along the cylindrical shank of the piston, the axis of which coincides with the longitudinal axis of the working cylinder of the damper. At least one longitudinal helical guide is made on the outer surface of that shank. This guide sets the longitudinal position of the support of the elastic element of the compression (expansion) valve on the cylindrical shank of the piston for each angle of turn of that support relative to the piston. A structural element, via which the support of the elastic element of the compression (expansion) valve interacts with the guide positioned on the shank of the piston, is positioned on the side surface of the support, which faces the cylindrical shank of the piston. The structural element via which the support of the elastic element of the compression (expansion) valve interacts with the guide made on the working cylinder of the damper, has the possibility of moving along that support in the direction of the longitudinal axis of the working cylinder of the damper by a distance at least equal to the maximum magnitude of movement of that support along the cylindrical shank of the piston.

### Brief Description of the Drawings and Diagrams

The instant application for the invention comprises drawings of devices, which illustrate the possibility of carrying out the proposed method for adjusting the resistance force of a liquid damper, and diagrams, which confirm the possibility of obtaining the claimed technical result when the proposed method is used.

Fig. 1 shows a device for carrying out the first main variant of the proposed method.

Fig. 2 shows a top view of part (6) and part (5) of the device shown in Fig. 1.

Fig. 3 shows a developed view of the inner surface of part (1) of the device shown in Fig. 1.

Fig. 4 shows a device for carrying out the third and fifth main variants of the proposed method.

Fig. 5 shows a top view of part (6), part (5) and part (25) of the device shown in Fig. 4.

Fig. 6 shows a developed view of the inner surface of part (1) of the device shown in Fig. 4.

Fig. 7 shows a device for carrying out the second main variant of the proposed method.

Fig. 8 shows a device for carrying out the fourth and sixth main variants of the proposed method.

Fig. 9 shows a device for carrying out the seventh main variant of the proposed method.

Fig. 10 shows a top view of part (13) and part (5) of the device shown in Fig. 9.

Figs. 11-36 show diagrams which confirm the possibility of attaining the claimed technical result when the proposed method is used. Three diagrams, each one of which corresponds to one of the following dampers, are shown on each drawing, with the exception of Fig. 11 and Fig. 12:

a) a damper in which a known method for adjusting the resistance force is used and which has a soft resistance characteristic (these diagrams are shown by a dotted line);

b) a damper in which a known method for adjusting the resistance force is used and which has a hard resistance characteristic (these diagrams are shown by a thin solid line);

c) a damper in which the proposed method for adjusting the resistance force is used (these diagrams are shown by a thick solid line).

Fig. 11 shows the relationship between the resistance force created by the damper and the absolute value of the speed of movement of the damper piston (resistance characteristic). Shown in this drawing are the resistance characteristics of a damper in which a known method for adjusting the resistance force is used and which has a soft resistance characteristic (dotted line) and of a damper in which a known method for adjusting the resistance force is used and which has a hard resistance characteristic (solid line). The forces created during forward movement of the piston (compression of the suspension of the vehicle) are shown in the negative branch of the coordinate system. The forces created during the return movement of the piston (expansion of the suspension of the vehicle) are shown in the positive branch of the coordinate system.

Fig. 12 shows the relationship between the damping of the sprung mass and the speed of movement of the damper piston for a damper in which the known method for adjusting a resistance force is used and which has a soft resistance characteristic (dotted line) and for a damper in which a known method for adjusting a resistance force is used and which has a hard resistance characteristic (solid line). The damping is calculated according to the equation:

$$D = 0.5 * (F_e / V + F_a / V) / (2 * (C * M)^{1/2})$$

where

D is the damping of the sprung mass;

$F_e$  is the resistance force of the damper during forward movement of the piston;

$F_a$  is the resistance force of the damper during return movement of the piston;

V is the absolute value of the speed of piston movement;

C is the rigidity of the elastic element of the suspension of the vehicle;

M is the value of the sprung mass of the vehicle.

Damping is calculated under condition that the kinematic transmission ratio is equal to one.

Fig. 13 shows a time diagram of oscillations of the sprung mass with sinusoidal external excitations with an amplitude of 20 mm and a repetition frequency approximately equal to the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 14 shows a time diagram of the force acting on the sprung mass with sinusoidal external excitations with an amplitude of 20 mm and a repetition frequency approximately equal to the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 15 shows a time diagram of oscillations of the sprung mass with sinusoidal external excitations with an amplitude of 20 mm and a repetition frequency approximately equal to twice the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 16 shows a time diagram of the force acting on the sprung mass with sinusoidal external excitations with an amplitude of 20 mm and a repetition frequency approximately equal to twice the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 17 shows a time diagram of oscillations of the sprung mass with sinusoidal external excitations with an amplitude of 50 mm and a repetition frequency

approximately equal to the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 18 shows a time diagram of the force acting on the sprung mass with sinusoidal external excitations with an amplitude of 50 mm and a repetition frequency approximately equal to the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 19 shows a time diagram of oscillations of the sprung mass with sinusoidal external excitations with an amplitude of 50 mm and a repetition frequency approximately equal to twice the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 20 shows a time diagram of the force acting on the sprung mass with sinusoidal external excitations with an amplitude of 50 mm and a repetition frequency approximately equal to twice the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 21 shows a time diagram of oscillations of the sprung mass with sinusoidal external excitations with an amplitude of 80 mm and a repetition frequency approximately equal to the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 22 shows a time diagram of the force acting on the sprung mass with sinusoidal external excitations with an amplitude of 80 mm and a repetition frequency approximately equal to the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 23 shows a time diagram of oscillations of the sprung mass with sinusoidal external excitations with an amplitude of 80 mm and a repetition frequency approximately equal to twice the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 24 shows a time diagram of the force acting on the sprung mass with sinusoidal external excitations with an amplitude of 80 mm and a repetition frequency approximately equal to twice the natural cyclic frequency of free oscillations of the sprung mass.

Fig. 25 shows a time diagram of oscillations of the sprung mass with a single external excitation of sinusoidal form with an amplitude of 20 mm and a duration approximately equal to the period of free oscillations of the sprung mass.

Fig. 26 shows a time diagram of the force acting on the sprung mass with a single external excitation of sinusoidal form with an amplitude of 20 mm and a duration approximately equal to the period of free oscillations of the sprung mass.

Fig. 27 shows a time diagram of oscillations of the sprung mass with a single external excitation of sinusoidal form with an amplitude of 20 mm and a duration approximately equal to one half the period of free oscillations of the sprung mass.

Fig. 28 shows a time diagram of the force acting on the sprung mass with a single external excitation of sinusoidal form with an amplitude of 20 mm and a duration approximately equal to one half the period of free oscillations of the sprung mass.

Fig. 29 shows a time diagram of oscillations of the sprung mass with a single external excitation of sinusoidal form with an amplitude of 50 mm and a duration approximately equal to the period of free oscillations of the sprung mass.

Fig. 30 shows a time diagram of the force acting on the sprung mass with a single external excitation of sinusoidal form with an amplitude of 50 mm and a duration approximately equal to the period of free oscillations of the sprung mass.

Fig. 31 shows a time diagram of oscillations of the sprung mass with a single external excitation of sinusoidal form with an amplitude of 50 mm and a duration approximately equal to one half the period of free oscillations of the sprung mass.

Fig. 32 shows a time diagram of the force acting on the sprung mass with a single external excitation of sinusoidal form with an amplitude of 50 mm and a duration approximately equal to one half the period of free oscillations of the sprung mass.

Fig. 33 shows a time diagram of oscillations of the sprung mass with a single external excitation of sinusoidal form with an amplitude of 80 mm and a duration approximately equal to the period of free oscillations of the sprung mass.

Fig. 34 shows a time diagram of the force acting on the sprung mass with a single external excitation of sinusoidal form with an amplitude of 80 mm and a duration approximately equal to the period of free oscillations of the sprung mass.

Fig. 35 shows a time diagram of oscillations of the sprung mass with a single external excitation of sinusoidal form with an amplitude of 80 mm and a duration approximately equal to one half the period of free oscillations of the sprung mass.

Fig. 36 shows a time diagram of the force acting on the sprung mass with a single external excitation of sinusoidal form with an amplitude of 80 mm and a duration approximately equal to one half the period of free oscillations of the sprung mass.

## Variants for Carrying Out the Invention

The first main variant of the proposed method may be carried out in the following manner. A piston of a damper is made of two elements. One aperture is made in the body of each of these elements. The apertures together form a constant restrictor. A structural element is included in the makeup of the damper. Control of the turn of one of the piston elements relative to the other piston element is effected by means of this structural element. During forward (return) movement of the piston in the working cylinder of the damper, the magnitude of the cross section of the slit of the compression (expansion) valve is changed in direct proportion to the value of the excessive pressure of the working liquid in the compression (expansion) chamber. In order to accomplish this, the force with which the excessive pressure acts on the plate of the compression (expansion) valve is balanced by the oppositely directed elastic force of the elastic element of that valve. Furthermore, by means of the structural element which controls the turn of one of the piston elements, movement of the piston is converted into a turn of that piston element relative to the other piston element. Wherewith, each position of the piston in the damper sets in accordance therewith an angle of turn of the piston elements relative to each other. And each such angle of turn sets in accordance therewith a degree of closure, by the movable element, of the aperture forming the constant restrictor and made in the other element of the piston. Thus each angle of turn of the piston elements relative to one another sets accordingly the magnitude of the flow cross section of the constant restrictor.

A device which is shown in Fig. 1 may be used to carry out the first main variant of the proposed method. This device is a liquid damper. The device has a cylindrical body (1), which simultaneously is the working cylinder of the damper, a compression chamber (2) and expansion chamber (3), which are formed as a result of dividing the damper cavity with a piston. The piston is secured to an end of a rod (4) and consists of two elements, element (5) and element (6). Both of these piston elements have the possibility of separately turning about the longitudinal axis of the damper. Apertures (7) and (8), which form a supply channel of a compression valve, and apertures (9) and (10), which form a supply channel of an expansion valve, are made in the body of the element (5). The compression valve includes a plate (11), which closes the apertures (7) and (8), an elastic element (12) and a support (13) for the elastic element. The expansion valve includes a plate (14), which closes the apertures (9) and (10), an elastic element (15) and

a support (16) of the elastic element. Parts of the valves and the element (5) are secured on the rod (4) by retaining rings (17). The element (6) is secured on the element (5) by the retaining ring (18). An aperture (19) is made in the body of the element (5). An aperture (20) is made in the body of the element (6). The apertures (19) and (20) form a constant restrictor which couples the compression chamber (2) and the expansion chamber (3). Two longitudinal guides are made on the inner surface of the body (1) on the section coinciding with the piston stroke. A guide (21) is made rectilinear and via a side protrusion (22) of the element (5) interacts with the element (5). A guide (23) is made helical and via a side protrusion (24) of the element (6) interacts with the element (6). At each point of the piston stroke, the central angle between the guide (21) and the guide (23) sets the angle of turn of the element (6) relative to the element (5). In the middle section of the piston stroke, which in this device corresponds to the maximum flow cross section of the constant restrictor, the central angle between the guide (21) and the guide (23) is equal to 180 degrees. The apertures (19) and (20) have identical angular dimensions and identical minimum and maximum radial spacing from the longitudinal axis of the damper. In element (5) the central angle between the protrusion (22) and the center of the aperture (19) is equal to 180 degrees. There is no such central angle in the element (6).

In the position of static balance, when the weight of the sprung mass of the vehicle is balanced by the elastic force of the elastic element of the suspension, the piston of the damper is in the middle of its stroke section. At that point of the piston stroke section, the value of the central angle between the guide (21) and the guide (23) is 180 degrees. Wherein, the position of the aperture (19) and the position of the aperture (20) completely coincide, and the magnitude of the flow cross section of the constant restrictor is maximum. In the position of static balance, there is no excessive pressure of the working liquid in the cavities of the damper and the compression and expansion valves are closed. During compression (expansion) of the suspension of the vehicle, forward (return) movement of the piston in the body (1) takes place, and an excessive pressure of the working liquid is produced in the compression (2) (expansion [3]) chamber. Under the effect of this pressure, the working liquid flows through the constant restrictor from the compression (2) (expansion [3]) chamber into the expansion (3) (compression [2]) chamber. At the same time, the excessive pressure acts on the plate (11) (plate [14]) of the compression (expansion) valve and causes movement of that plate and elastic deformation of the elastic element (12) (elastic element [15]). The elastic force of the



elastic element which is produced thereby compensates the force with which the excessive pressure acts on the plate (11) (plate [14]). As a result, the plate of the valve is fixed at some position. This position of the plate determines the size of the cross section of the slit of that valve, corresponding to the current value of the excessive pressure.

Furthermore, when the piston moves along the body (1), the element (6) turns relative to the element (5) as a result of the interaction of those elements with the guides (23) and (21). The angle of that turn at each point of the piston stroke section is determined by the value of the central angle between the guide (21) and the guide (23). Wherewith, the aperture (20) is shifted relative to the aperture (19) by that same angle and a change in the flow cross section of the constant restrictor occurs.

The third main variant of the proposed method may be carried out in the following manner. The piston of the damper is made of three elements. Two apertures, positioned at different distances from the longitudinal axis of the damper, are made in the body of each of those piston elements. The apertures of the three elements that are spaced at the greatest distance from the longitudinal axis of the damper are used as a supply channel of the compression valve. The apertures which are spaced at the smallest distance from the longitudinal axis of the damper are used as the supply channel of the expansion valve. The makeup of the damper includes a structural element, by means of which control of the turn of the outer elements of the piston relative to the element positioned in the middle of the piston is effected. During forward (return) movement of the piston in the working cylinder of the damper, the size of the cross section of the slit of the compression (expansion) valve is changed in direct proportion to the value of the excessive pressure of the working liquid in the compression (expansion) chamber. For this, the force with which the excessive pressure acts on the plate of the compression (expansion) valve is balanced by the oppositely directed elastic force of the elastic element of that valve. Furthermore, by means of the structural element which effects control by turning the outer elements of the piston, movement of the piston is converted into a turn of one outer element of the piston relative to the middle element of the piston, and also into a turn of the other outer element of the piston relative to the middle element of the piston. Wherein, each position of the piston in the damper sets in accordance therewith an angle of turn of one outer piston element relative to the middle piston element and an angle of turn of the other outer piston element relative to the middle piston element. The angle of turn of the piston element positioned at the side of the expansion chamber sets in accordance therewith the degree of closure of the apertures forming the supply channel of

the compression valve, and accordingly the magnitude of the flow cross section of that channel. The angle of turn of the piston element positioned at the side of the compression chamber set in accordance therewith the degree of closure of the apertures forming the supply channel of the expansion valve, and accordingly the magnitude of the flow cross section of that channel.

The fifth main variant of the proposed method is carried out in a manner similar to that of the third main variant and has the following additional features as compared with the third variant. All of the apertures forming the supply channels of the compression and expansion valves are made in the form of sectors of a ring. One radial side of each of the apertures made in the middle element of the piston is limited by a protrusion. This protrusion passes through the outlet aperture of the supply channel of the compression (expansion) valve and together with the surface of the outer element of the piston, which limits this outlet aperture, forms the seat of the compression (expansion) valve. When an outer element of the piston turns relative to the middle element of the piston, not only the degree of closure of the apertures forming the supply channel of a corresponding valve and the flow cross section of that channel are changed, but also the area limited by the seat of that valve. Thus, each angle of turn of an outer piston element sets in accordance therewith the force with which the excessive pressure of the working liquid acts on the plate of a valve, and accordingly the magnitude of the cross section of the slit of that valve at a constant excessive pressure.

The device which is shown in Fig. 4 may be used in order to carry out the third and fifth main variants of the proposed method. This device is a liquid damper. The device has a cylindrical body (1), which at the same time is the working cylinder of the damper, compression (2) and expansion (3) chambers, which are formed as a result of dividing the cavity of the damper with a piston. The piston is secured to an end of a rod (4) and consists of three elements, element (5), element (25) and element (6). All three piston elements have the possibility of separately turning about the longitudinal axis of the damper. Apertures (20), (7) and (26), which form the supply channel of the compression valve, and apertures (27), (10) and (28), which form the supply channel of the expansion valve, are made in the bodies of those piston elements. All of these apertures have the form of a sector of a ring. The compression valve includes a plate (11), which covers the aperture (20), an elastic element (12), and a support (13) of the elastic element. The expansion valve includes a plate (14) which covers the aperture (27), an elastic element (15) and a support of the elastic element (16). The parts of the

valves and the piston elements are secured on a rod (4) by retaining rings (17). The aperture (7) is limited on one radial side by a protrusion (29) which passes through the aperture (20) and together with a surface of the piston element (6) forms a seat of the compression valve. The aperture (10) is limited on one radial side by a protrusion (30) which passes through the aperture (27) and together with a surface of the piston element (25) forms a seat of the expansion valve. Three longitudinal guides are made on the section of the inner surface of the body (1), which coincides with the stroke of the piston. A guide (21) is made rectilinear and via a side protrusion (22) of the element (5) interacts with the element (5). A guide (23) is made helical and via side protrusion (32) of the element (25) interacts with the element (25). A guide (31) is made helical and via side protrusion (32) of element (25) interacts with element (25). At each point of the piston stroke the central angle between the guide (23) and the guide (21) sets the angle of turn of the element (6) relative to the element (5), and the central angle between the guide (31) and the guide (21) sets the angle of turn of the element (25) relative to the element (5). In the middle section of the piston stroke, which in this device corresponds to the maximum flow cross section of the supply channels of the compression and expansion valves, the central angles between the guides (23) and (21) and between the guides (31) and (21) are equal to 90 degrees. The apertures (20), (7) and (26) have identical minimum and maximum spacing from the longitudinal axis of the damper. The apertures (28), (10) and (27) also have identical minimum and maximum spacing from the longitudinal axis of the damper. Wherewith the minimum distance of the apertures of the first group is greater than the maximum distance of the apertures of the second group. When the piston is in the middle section of its stroke, the apertures (20) and (7) and the apertures (27) and (10) coincide. Wherein, the flow cross sections of the supply channels of the compression and expansion valves are maximum. The area of the seat of the compression valve and the area of the seat of the expansion valve also have maximum values in that position of the piston.

In the position of static balance, when the weight of the sprung mass of the vehicle is balanced by the elastic force of the elastic element of the suspension, the piston of the damper is in the middle of its stroke section. At that point of the piston stroke section, the central angles between the guide (21) and the guide (23) and between the guide (31) and the guide (21) are equal to 90 degrees. Wherein, the position of the aperture (7) and the position of the aperture (20) coincide, and the magnitude of the flow cross section of the supply channel of the compression valve is maximum. The position of the aperture

(10) and the position of the aperture (27) also coincide and the magnitude of the flow cross section of the supply channel of the expansion valve is maximum. Furthermore, in that position of the piston the area of the compression valve seat and the area of the expansion valve seat have their maximum values. In the position of static balance, there is no excessive pressure of the working liquid in the cavities of the damper and the compression and expansion valves are closed. During compression (expansion) of the suspension of the vehicle, forward (return) movement of the piston in the body (1) takes place, and an excessive pressure of the working liquid is produced in the compression (2) (expansion [3]) chamber. The excessive pressure acts on the plate (11) (plate [14]) of the compression (expansion) valve and causes movement of that plate and elastic deformation of the elastic element (12) (elastic element [15]). The elastic force of the elastic element which is produced thereby compensates the force with which the excessive pressure acts on the plate (11) (plate [14]). As a result, the plate of the valve is fixed at some position. This position of the plate determines the size of the cross section of the slit of that valve, corresponding to the current value of the excessive pressure. Furthermore, when the piston moves along the body (1), the element (6) turns relative to the element (5) and the element (25) relative to the element (5) as a result of the interaction of those elements with the guides (23), (21) and (31). The angles of those turns at each point of the piston stroke section are determined by the value, respectively, of the central angle between the guide (23) and the guide (21) and the central angle between the guide (31) and the guide (21). Wherewith, the aperture (20) is shifted relative to the aperture (7) and a change occurs in the flow cross section of the supply channel of the compression valve, while the aperture (27) is shifted relative to the aperture (10) and a change in the flow cross section of the supply channel of the expansion valve occurs. Furthermore, movement of the protrusion (29) into the aperture (20) and movement of the protrusion (30) into the aperture (27) take place. As a result, a change of the area of the seat of the compression valve and of the area of the seat of the expansion valve occurs. The change of the area of the seat of the compression valve results in a change in the force with which the excessive pressure in the compression chamber (2) acts on the plate (11), which in turn results in a change in the height of the slit of the compression valve and, accordingly, to a change in the cross section of that slit. A change in the area of the seat of the expansion valve results in a change of the force with which the excessive pressure in the expansion chamber (3) acts on the plate (14), which in turn results in a change in the height of the slit of the expansion valve, and, accordingly, a change in the cross section of that slit.

The increased angular size of the aperture (26) for any possible angle of turn of the element (25) relative to element (5) ensures the supply of such an amount of working liquid into the supply channel of the compression valve that corresponds to the maximum flow cross section of the compression valve. The increased angular size of the aperture (28) for any possible angle of turn of the element (6) relative to element (5) ensures the supply of an amount of working liquid into the supply channel of the expansion valve that corresponds to the maximum flow cross section of the expansion valve.

The second main variant of the proposed method may be carried out in the following manner. The damper piston includes a movable gate which as a result of its displacement relative to the piston closes the aperture forming the constant restrictor. The damper includes a structural element by means of which control of the displacement of the movable gate relative to the piston is carried out. During forward (return) movement of the piston in the working cylinder of the damper, the size of the cross section of the slit of the compression (expansion) valve is changed in direct proportion to the value of the excessive pressure of the working liquid in the compression (expansion) chamber. For this, the force with which the excessive pressure acts on the plate of the compression (expansion) valve is balanced by the oppositely directed elastic force of the elastic element of that valve. Furthermore, by means of the structural element, which controls displacement of the movable gate, movement of the piston is converted into displacement of the movable gate relative to the piston. Wherein, each position of the piston in the damper sets in accordance therewith a position of the gate relative to the piston. And each such gate position sets in accordance therewith a value of closure of the aperture, forming the constant restrictor, in accordance therewith, and, accordingly, a magnitude of the flow cross section of the constant restrictor.

The device which is shown in Fig. 7 may be used in order to carry out the second main variant of the proposed method. This device is a liquid damper. The device has a cylindrical body (1), which at the same time is the working cylinder of the damper, compression (2) and expansion (3) chambers, which are formed as a result of dividing the cavity of the damper with a piston. The piston is secured to an end of a rod (4) and consists of a main element (5) and a movable gate (33). The movable gate (33) is positioned in a recess of the main piston element (5) and has the possibility of moving along that recess. Apertures (7) and (8), which form the supply channel of the compression valve, and apertures (9) and (10), which form the supply channel of the expansion valve, are made in the body of the element (5). The compression valve includes

a plate (11), which covers the aperture (7) and (8), an elastic element (12), and a support (13) of the elastic element. The expansion valve includes a plate (14) which covers the apertures (9) and (10), an elastic element (15) and a support of the elastic element (16). The valve parts and the element (5) are secured on the rod (4) by retaining rings (17). An aperture (19), which forms a constant restrictor coupling the compression chamber (2) and the expansion chamber (3), is made in the body of the element (5). A rectilinear longitudinal guide (21), which interacts with the gate (33) is made on the inner surface of the body (1) on the section coinciding with the stroke of the piston. In order to ensure a constant contact with the guide (21), the gate (33) is pressed against it by an elastic element (34). The guide (21) has a varying transverse profile. In each point of the stroke of the piston, the transverse profile of the guide (21) sets the position of the gate (33) relative to the piston element (5). On the middle section of the stroke of the piston, which in this case corresponds to the maximum flow cross section of the constant restrictor, the guide (21) has a transverse profile of maximum depth.

In the position of static balance, when the weight of the sprung mass of the vehicle is balanced by the elastic force of the elastic element of the suspension, the piston of the damper is in the middle of its stroke section. At that point of the piston stroke section, the guide (21) has a transverse profile of maximum depth. Wherein the gate (33) completely opens the aperture (19) and the size of the flow cross section of the constant restrictor is maximum. In the position of static balance, there is no excessive pressure of the working liquid in the cavities of the damper and the compression and expansion valves are closed. During compression (expansion) of the suspension of the vehicle, forward (return) movement of the piston in the body (1) takes place, and an excessive pressure of the working liquid is produced in the compression (2) (expansion [3]) chamber, due to the action of which the working liquid flows through the constant restrictor from the compression (2) (expansion [3]) chamber into the expansion (3) (compression [2]) chamber. At the same time, the excessive pressure acts on the plate (11) (plate [14]) of the compression (expansion) valve and causes movement of that plate and elastic deformation of the elastic element (12) (elastic element [15]). The elastic force of the elastic element which is produced thereby compensates the force with which the excessive pressure acts on the plate (11) (plate [14]). As a result, the plate of the valve is fixed at some position which determines the size of the cross section of the slit of that valve, corresponding to the current value of the excessive pressure. Furthermore, when the piston moves along the body (1), the gate (33) moves relative to the piston

element (5) as a result of the interaction of the gate with the guide (21). The magnitude of that movement in each point of the piston stroke section is determined by the transverse profile of the guide (21). Due to the movement, the gate (33) closes the aperture (19) with its body and a change in the flow cross section of the constant restrictor takes place.

The fourth main variant of the proposed method may be carried out in the following manner. The damper piston includes two movable gates, one of which as a result of its displacement relative to the piston closes the supply channel of the compression valve, while the other as a result of similar displacement closes the supply channel of the expansion valve. The damper includes a structural element by means of which control of the displacement of the movable gates relative to the piston is carried out. During forward (return) movement of the piston in the working cylinder of the damper, the size of the cross section of the slit of the compression (expansion) valve is changed in direct proportion to the value of the excessive pressure of the working liquid in the compression (expansion) chamber. For this, the force with which the excessive pressure acts on the plate of the compression (expansion) valve is balanced by the oppositely directed elastic force of the elastic element of that valve. Furthermore, by means of the structural element, which controls displacement of the movable gates, movement of the piston is converted into displacement of those movable gates relative to the piston. Wherein, each position of the piston in the damper sets in accordance therewith a position of the first (second) gate relative to the piston. And each such gate position sets in accordance therewith a value of closure of the supply channel of the compression (expansion) valve by the first (second) gate, and, accordingly, a magnitude of the flow cross section of the supply channel of the compression (expansion) valve.

The sixth main variant of the proposed method is carried out in a manner similar to the manner in which the fourth main variant is carried out with the following additional features. The apertures which form the supply channels of the compression and expansion valves are made in the form of rectangles. The movable gates are provided with protrusions which pass through the apertures of the supply channels to the opposite side of the piston and together with the surface of the piston, limiting the aperture of the supply channel, form seats of the compression and expansion valves. When the first (second) gate is moved relative to the piston, not only the flow cross section of the supply channel of the compression (expansion) valve is changed, but also the area limited by the seat of that valve. Thus, each position of the first (second) movable gate relative to the

piston sets in accordance therewith a force with which the excessive pressure of the working liquid acts on the plate of the compression (expansion) valve, and, accordingly the magnitude of the cross section of the slit of that valve for a constant excessive pressure.

5           The device shown in Fig. 8 may be used to carry out the fourth and sixth main variants of the proposed method. This device is a liquid damper. The device has a cylindrical body (1), which at the same time is the working cylinder of the damper, a compression chamber (2) and an expansion chamber (3), which are formed as a result of dividing the cavity of the damper with a piston. The piston is secured to an end of the  
10   rod (4) and consists of a main element (5), a movable gate (33) and a movable gate (35). The movable gates (33) and (35) are positioned in recesses of the main piston element (5) and have the possibility of moving along those recesses. An aperture (7), which forms a supply channel of the compression valve, and an aperture (9), which forms a supply  
15   channel of the expansion valve, are made in the body of the element (5). The compression valve includes a plate (11), which closes the aperture (7), an elastic element (12) and a support (13) of the elastic element. The expansion valve includes a plate (14), which closes the aperture (9), an elastic element (15) and a support (16) of the elastic element. Longitudinal slots, which prevent the plates (11) and (14) from turning  
20   relative to the element (5), are made in the shanks of the piston (5). The parts of the valves and the piston are secured on the rod (4) by a retaining ring (17). A rectilinear longitudinal guide (21), which interacts with the gate (33), and a rectilinear guide (36), which interacts with the gate (35), are made on the inner surface of the body (1) on the section coinciding with the stroke of the piston. In order to ensure a constant contact  
25   with the guides (21) and (36), the gates (33) and (35) are pressed against them by the elastic elements (34) and (37). The guides (21) and (36) have a varying transverse profile. At each point of the stroke of the piston, the transverse profile of the guide (21) sets a position of the gate (33) relative to the piston element (5). At each point of the stroke of the piston, the transverse profile of the guide (36) sets a position of the gate (35) relative to the piston element (5). At the middle section of the stroke of the piston, which  
30   in this device corresponds to the maximum flow cross section of the compression (expansion) channel with the compression (expansion) valve completely open, the guides (21) and (36) have a transverse profile of maximum depth. The gate (33) has a protrusion which passes through the aperture (7) and together with the surface of the element (5) forms a seat of the compression valve. The gate (35) has a protrusion which



passes through the aperture (9) and together with the surface of the element (5) forms a seat of the expansion valve.

In the position of static balance, when the weight of the sprung mass of the vehicle is balanced by the elastic force of the elastic element of the suspension, the piston of the damper is in the middle of its stroke section. At that point of the piston stroke section, the guides (21) and (36) have a transverse profile of maximum depth. Wherein the gates (33) and (35) completely open the apertures (7) and (9). In that position the flow cross sections of the supply channels of the compression and expansion valves, and also the areas of the seats of those valves are maximum. In the position of static balance, there is no excessive pressure of the working liquid in the cavities of the damper and the compression and expansion valves are closed. During compression (expansion) of the suspension of the vehicle, forward (return) movement of the piston in the body (1) takes place, and an excessive pressure of the working liquid is produced in the compression (2) (expansion [3]) chamber, which acts on the plate (11) (plate [14]) of the compression (expansion) valve and causes movement of that plate and elastic deformation of the elastic element (12) (elastic element [15]). The elastic force of the elastic element which is produced thereby compensates the force with which the excessive pressure acts on the plate (11) (plate [14]). As a result, the plate of the valve is fixed at some position which determines the size of the cross section of the slit of that valve, corresponding to the current value of the excessive pressure. Furthermore, when the piston moves along the body (1), the gates (33) and (35) move relative to the piston element (5) as a result of the interaction of the gates with the guides (21) and (36). At each point of the piston stroke section the position of the gate (33) is determined by the transverse profile of the guide (21), while the position of the gate (35) is determined by the transverse profile of the guide (36). Due to the movement, the gate (33) (gate [35]) closes the aperture (7) (aperture [9]) with its body, and a change in the flow cross section of the supply channel of the compression (expansion) valve takes place. Furthermore, due to displacement of the protrusion of the gate, the area of the seat of that valve changes. A change in the area of the seat of the compression valve results in a change of the force with which the excessive pressure in the compression chamber (2) acts on the plate (11), which in turn results in a change in the height of the slit of the compression valve, and accordingly, to a change in the cross section of that slit. A change in the area of the seat of the expansion valve results in a change of the force with which the excessive pressure in the expansion

chamber (3) acts on the plate (14), which in turn results in a change in the height of the slit of the expansion valve, and, accordingly, in a change in the cross section of that slit.

The seventh main variant of the proposed method may be carried out in the following manner. The makeup of the damper includes a structural element which controls the linear displacement of the supports of the elastic elements of the compression and expansion valves along the longitudinal axis of the working cylinder relative to the seats of those valves. During the forward (return) movement of the piston in the working cylinder of the damper, the size of the cross section of the slit of the compression (expansion) valve is changed in direct proportion to the value of the excessive pressure of the working liquid in the compression (expansion) chamber. For this, the force with which the excessive pressure acts on the plate of the compression (expansion) valve is balanced by the oppositely directed elastic force of the elastic element of that valve. Furthermore, by means of a structural element which controls displacement of the supports of the elastic elements of the valves, the movement of the piston is converted into linear displacement of those supports relative to the seats of corresponding valves. Each position of the piston in the working cylinder of the damper sets in accordance therewith a linear position of the support of the elastic element of the compression (expansion) valve relative to the seat of that valve, and each such position of the support sets in accordance therewith a value of an elastic deformation of the elastic element of that valve and an elastic force which it creates. Thus, each position of the support of the elastic element of the compression (expansion) valve sets in accordance therewith a value of the cross section of the slit of that valve corresponding to a constant excessive pressure in the compression (expansion) chamber.

The device shown in Fig. 9 may be used to carry out the seventh main variant of the proposed method. This device is a liquid damper. The device has a cylindrical body (1), which at the same time is the working cylinder of the damper, a compression chamber (2) and an expansion chamber (3), which are formed as a result of dividing the cavity of the damper with a piston. The piston is secured to an end of the rod (4) and consists of a main element (5) which has cylindrical shanks. Apertures (7) and (8), which form a supply channel of the compression valve, and apertures (9) and (10), which form a supply channel of the expansion valve, are made in the body of the element (5). The compression valve includes a plate (11), which closes the apertures (7) and (8), an elastic element (12) and a support (13) of the elastic element. The expansion valve includes a plate (14), which closes the apertures (9) and (10), an elastic element (15) and a support

(16) of the elastic element. The parts of the valves and the element (5) are secured on the rod (4) by a retaining ring (17). . Three longitudinal guides are made on the section of the inner surface of the body (1), which coincides with the stroke of the piston. A guide (21) is made rectilinear and via a side protrusion (22) of the element (5) interacts with the element (5). A guide (23) is made helical and via a pin (38), which is mounted in the support (13), interacts with the support (13). A guide (31) is made helical and via a pin (39), which is mounted in the support (16), interacts with the support (16). The developed view of the inner surface of the working cylinder (1) is similar to the developed view shown in Fig. 6. At each point of the piston stroke the central angle between the guide (23) and the guide (21) sets the angle of turn of the support (13) relative to the element (5), and the central angle between the guide (31) and the guide (21) sets the angle of turn of the support (16) relative to the element (5). In the middle section of the piston stroke, which in this device corresponds to the maximum cross section of the slits of the compression and expansion valves at a constant value of the excessive pressure of the working liquid, the central angles between the guides (23) and (21) and between the guides (31) and (21) are equal to 90 degrees. A helical guide is made on the outer surface of each shank of the element (5). The support (13) interacts with a guide (40) via a side protrusion (41). The support (16) interacts with a guide (42) via a side protrusion (43). For each angle of turn of the support (13) relative to the element (5), the guide (40) sets a linear position of the support (13) relative to the seat of the compression valve. For each angle of turn of the support (16) relative to the element (5), the guide (42) sets the linear position of the support (16) relative to the seat of the expansion valve. In order to prevent seizure in the guide (23), the pin (38) has the possibility of longitudinal displacement in the support (13) by a value equal to the longitudinal size of the guide (40). In order to prevent seizure in the guide (31), the pin (39) has the possibility of longitudinal displacement in the support (16) by a value equal to the longitudinal size of the guide (42).

In the position of static balance, when the weight of the sprung mass of the vehicle is balanced by the elastic force of the elastic element of the suspension, the piston of the damper is in the middle of its stroke section. At that point of the piston stroke section, the central angles between the guide (21) and the guide (23) and between the guide (31) and the guide (21) are equal to 90 degrees. In that position, the supports (13) and (16) are spaced maximum from the seats of the compression and expansion valves. In the position of static balance, there is no excessive pressure of the working liquid in the

cavities of the damper, and the compression and expansion valves are closed. During compression (expansion) of the vehicle suspension, a forward (return) movement of the piston in the body (1) takes place, and an excessive pressure of the working liquid is produced, which acts on the plate (11) (plate[14]) of the compression (expansion) valve and causes displacement of that plate and elastic deformation of the elastic element (12) (elastic element [15]). The elastic force of the elastic element produced thereby compensates the force with which the excessive pressure acts on the plate (11) (plate [14]). As a result of this, the plate of the valve is fixed at a position which determines the size of the cross section of the slit of that valve, corresponding to the current value of the excessive pressure. Furthermore, when the piston moves along the body (1), the support (13) turns relative to the element (5) and the support (16) turns relative to the element (5) as a result of the interaction of the supports with the guides (23) and (31). The angle of turn of the support (13) at each point of the piston stroke section is determined by the central angle between the guide (23) and the guide (21). The angle of turn of the support (16) at each point of the piston stroke section is determined by the central angle between the guide (31) and the guide (21). In the process of turning relative to the piston, the support (13) moves along the helical guide (40) and changes its position relative to the seat of the compression valve. Wherein, a change in the elastic deformation of the elastic element (12) and a change in the created thereby elastic force take place. The position of the plate (11) and the cross section of the slit of the compression valve, which correspond to a constant excessive pressure in the compression chamber (2) change as a result of a change of the elastic force. In the process of turning relative to the piston, the support (16) moves along the helical guide (42) and changes its position relative to the seat of the expansion valve. Wherein, a change in the elastic deformation of the elastic element (15) and a change in the elastic force created thereby take place. As a result of a change in the elastic force, the position of the plate (14) and the cross section of the slit of the expansion valve, which correspond to a constant excessive pressure in the expansion chamber (3), take place.

Information confirming the possibility of attaining the claimed technical results when the proposed method is carried out is provided in Figs. 13-36 in the form of time diagrams of oscillations of the sprung mass of a vehicle and time diagrams of the force acting on the sprung mass during the forced oscillations thereof which are caused by external excitation of various amplitude and repetition frequency. A description of the content of the diagrams and their conditional designations are presented in the section

"List of drawings and diagrams." Each drawing contains three diagrams and makes it possible to compare oscillation of the sprung mass or the force acting thereon for the cases in which the following dampers are used in the suspension of a vehicle:

a) a damper in which a known method for adjusting the resistance force is used and which has a soft resistance characteristic;

b) a damper in which a known method for adjusting the resistance force is used and which has a hard resistance characteristic;

c) a damper in which the proposed method for adjusting the resistance force is used.

The presented time diagrams were obtained by mathematical simulation of the process of forced oscillations of the sprung mass, in relation to one wheel of the vehicle. The used mathematical model takes into account the influence exerted by the damper, the elastic element of the suspension, compression buffer, expansion buffer, the elasticity and damping provided by a tire, a change in the unsprung mass in the process of compression (expansion) of the suspension.

For a more complete evaluation of the degree of influence of the dampers being compared on the oscillation process, the resistance characteristics of the dampers being compared in which the known method for adjusting the resistance force is used are shown in Fig. 11, and the damping which these dampers provide in the simulated oscillation process is shown in Fig. 12.

The best variant for carrying out the invention is the fifth main variant of the proposed method. This variant is described in the instant section of the specification.

## Set of Claims

1. A method for adjusting the resistance force of a liquid damper, the cavity of which is divided into at least two chambers, the volume of one of which, a compression (expansion) chamber, is reduced, and the volume of another, an expansion (compression) chamber, is increased during forward (return) movement of a piston dividing them, the piston being positioned in a working cylinder of the damper, wherein due to the action of an excessive pressure formed in the compression (expansion) chamber relative to other cavities of the damper, during forward (return) movement of the piston working liquid flows through a compression (expansion) channel which couples the compression (expansion) chamber to other cavities of the damper, the action of the excessive pressure of the working liquid on parts of the damper creates a resistance force of the damper, mechanical energy spent on displacing the piston is consumed to accomplish work on overcoming said resistance force, wherein in order to adjust the resistance force of the damper a flow cross section of the compression (expansion) channel is changed depending on the value of the excessive pressure, wherefore the force with which the excessive pressure acts on a movable element of a compression (expansion) valve, a current position of which determines a current linear size of a slit of that valve, is balanced by an oppositely directed elastic force of an elastic element of that valve, **characterized** in that controlled displacement is provided for at least one part of the damper whose position relative to another part of the damper affects the size of the flow cross section of the compression (expansion) channel, the forward (return) movement of the piston is converted into a change of the position of those parts relative to one another, wherein each position of the piston in the working cylinder of the damper sets in accordance therewith a position of those parts relative to one another, and each such position of the parts sets in accordance therewith a value of the flow cross section of the compression (expansion) channel corresponding to a constant value of the excessive pressure.

2. A method according to claim 1, characterized in that the forward (return) movement of the piston is converted into a turn of a damper part, closing a constant restrictor, relative to a damper part in which an aperture of the constant restrictor is made, each angle of turn of those parts relative to one another sets in accordance therewith a degree of closure of the aperture of the constant restrictor by a movable part.

3. A method according to claim 1, characterized in that the forward (return) movement of the piston is converted into a linear displacement of a damper part, closing a constant restrictor, relative to a damper part in which an aperture of the constant restrictor is made, each position of those parts relative to one another sets in accordance therewith a degree of closure of the aperture of the constant restrictor by a movable part.

4. A method according to claim 1, characterized in that the forward (return) movement of the piston is converted into a turn of a damper part, closing a supply channel of the compression (expansion) valve, relative to a damper part in which an aperture of that supply channel is made, each angle of turn of those parts relative to one another sets in accordance therewith a degree of closure of the aperture of the supply channel by a movable part.

5. A method according to claim 1, characterized in that the forward (return) movement of the piston is converted into linear displacement of a damper part, closing a supply channel of the compression (expansion) valve, relative to a damper part in which an aperture of that supply channel is made, each position of those parts relative to one another sets in accordance therewith a degree of closure of the aperture of the supply channel by a movable part.

6. A method according to claim 1, characterized in that the forward (return) movement of the piston is converted into a turn of a damper part relative to another damper part which together with the first part forms a seat of the compression (expansion) valve, each angle of turn of those parts relative to one another sets in accordance therewith a size of an area limited by the seat of the compression (expansion) valve and a force with which the excessive pressure of the working liquid in the compression (expansion) chamber acts on the movable element of the compression (expansion) valve, the current position of which determines the current linear size of the slit of that valve.

7. A method according to claim 1, characterized in that the forward (return) movement of the piston is converted into a linear displacement of a damper part relative to another damper part which together with the first part forms a seat of the compression (expansion) valve, each position of those parts relative to one another sets in accordance therewith a size of an area limited by the seat of the compression (expansion) valve and a force with which the excessive pressure of the working liquid in the compression (expansion) chamber acts on the movable element of the compression (expansion) valve, the current position of which determines the current linear size of the slit of that valve.

8. A method according to claim 1, characterized in that the forward (return) movement of the piston is converted into linear displacement of a support of the elastic element of the compression (expansion) valve relative to a seat of that valve, each position of the support relative to the seat sets in accordance therewith a value of elastic deformation of the elastic element of the compression (expansion) valve and an elastic force with which the elastic element acts on the movable element of the valve, the current position of which determines the current linear size of the slit of that valve.

9. A device for adjusting the resistance force of a liquid damper, which device is a liquid damper and has compression and expansion chambers, formed as a result of dividing a cavity of the damper with a piston which is secured to a rod and consists of at least two elements, a compression (expansion) channel, through which there is a flow of a working liquid from the compression (expansion) chamber to the expansion (compression) chamber during forward (return) movement of the piston in a working cylinder of the damper and which includes at least a compression (expansion) valve which has a supply channel made in a body of the piston, a plate covering an outlet aperture of the supply channel from the side of the expansion (compression) chamber, and an elastic element, the action of the elastic force of which on the plate is directed towards the piston, **characterized** in that at least two piston elements have the possibility of separately turning about the longitudinal axis of the working cylinder of the damper, a cylindrical structural element is provided coaxial with the rod of the damper, at least two longitudinal guides are made on a section of the surface of the cylindrical structural element, at least one of the guides is made helical, in each point of the piston stroke a central angle between the guides sets an angle of turn of a first piston element relative to a second element, at least one structural element is positioned on a side surface of both the first and the second piston elements which faces the cylindrical structural element, via the structural element the first piston element interacts with one of the guides of the cylindrical structural element, and the second piston element interacts with another guide of the cylindrical structural element, at least two apertures forming a through channel in the body of the piston, one of which is made in the first piston element, the other is made in the second piston element, when the piston is in a position corresponding to a minimum flow cross section of the compression (expansion) channel with the compression (expansion) valve completely open, the cross section of the channel formed by those apertures is at the most less than the flow cross section of that same channel when the piston is in a position corresponding to a maximum flow cross section of the



compression (expansion) channel with the compression (expansion) valve completely open.

10. A device according to claim 9, characterized in that the guides with which the piston elements interact are made on the inner surface of the working cylinder of the damper.

11. A device according to claim 9, characterized in that the rod of the damper is made hollow, the guides with which the piston elements interact are made on the external surface of a pin which is secured on the bottom of the compression chamber and which moves into a cavity of the rod during forward movement of the piston.

12. A device according to claim 10 or claim 11, characterized in that the piston of the damper is provided with a third element which is similar to the first two elements and is positioned from the side of the compression chamber or the expansion chamber, an additional longitudinal guide, similar to the other guides, is made on the surface of the cylindrical structural element, the third piston element interacts with the additional guide, in each point of the piston stroke a central angle between that guide and a guide interacting with the piston element positioned in the middle of the piston sets an angle of turn of those piston elements relative to one another, the supply channel of the compression (expansion) valve is formed by at least three apertures, each of which is made in one of the three piston elements, these apertures have the form of a sector of a ring with a center on the longitudinal axis of the working cylinder of the damper and have equal external and internal radii, a radial side of an aperture of the supply channel of the compression (expansion) valve made in the piston element positioned in the middle of the piston, which during reduction of the flow cross section of that supply channel approaches the radial side of the outlet aperture of that same supply channel, is limited by a protrusion of the piston element, the protrusion has the form of a sector of a ring with a center on the longitudinal axis of the working cylinder of the damper and extends through the outlet aperture of the supply channel of the compression (expansion) valve, this protrusion together with the piston element surface which limits the outlet aperture from the side of the expansion (compression) chamber forms a seat of the compression (expansion) valve, in each point of the piston stroke the flow cross section, formed by the inlet aperture of the supply channel of the compression (expansion) valve and the aperture of that same supply channel which is made in the piston element positioned in the middle of the piston, is at least equal to the flow cross section formed by the latter aperture and the outlet aperture of the supply channel of the compression (expansion) valve.

13. A device for adjusting the resistance force of a liquid damper, which device is a liquid damper and has compression and expansion chambers, formed as a result of dividing a cavity of the damper with a piston which is secured to a rod, a compression (expansion) channel, through which there is a flow of a working liquid from the compression (expansion) chamber to the expansion (compression) chamber during forward (return) movement of the piston in a working cylinder of the damper and which includes at least a compression (expansion) valve which has a plate covering an outlet aperture of the supply channel of that valve from the side of the expansion (compression) chamber, an elastic element, the elastic deformation of which occurs along the longitudinal axis of the working cylinder of the damper, and a support of the elastic element, which fixes the position of the end of the elastic element opposite the piston relative to a seat of the compression (expansion) valve, **characterized** in that the piston of the damper and the support of the elastic element of the compression (expansion) valve have the possibility of separately turning about the longitudinal axis of the working cylinder of the damper, at least two longitudinal guides are made on the inner surface of the working cylinder of the damper on the section coinciding with the piston stroke, at least one of the longitudinal guides is made helical, in each point of the piston stroke a central angle between the guides sets an angle of turn of the support of the elastic element of the compression (expansion) valve relative to the piston, a structural element, via which the piston interacts with one of the guides, is positioned on a side surface of the piston facing the inner surface of the working cylinder of the damper, a structural element via which the support of the elastic element of the compression (expansion) valve interacts with another guide is positioned on a side surface of that support, the support of the elastic element of the compression (expansion) valve has the possibility of moving along a cylindrical shank of the piston, the axis of which shank coincides with the longitudinal axis of the working cylinder of the damper and on the external surface of which at least one longitudinal helical guide is made, this guide sets a longitudinal position of the support of the elastic element of the compression (expansion) valve on the cylindrical shank of the piston for each angle of turn of that support relative to the piston, a structural element, via which the support of the elastic element of the compression (expansion) valve interacts with the guide positioned on the shank of the piston, is positioned on a side surface of that support facing the cylindrical shank of the piston, the structural element, via which the support of the elastic element of the compression (expansion) valve interacts with the guide made on the working cylinder of the damper,

has the possibility of moving along that support in the direction of the longitudinal axis of the working cylinder of the damper by a length at least equal to the maximum length of movement of that support along the cylindrical shank of the piston.

14. A device for adjusting the resistance force of a liquid damper, which device is a liquid damper and has compression and expansion chambers, formed as a result of dividing a cavity of the damper with a piston which is secured to a rod, a compression (expansion) channel, through which there is a flow of a working liquid from the compression (expansion) chamber to the expansion (compression) chamber during forward (return) movement of the piston in a working cylinder of the damper and which includes at least a compression (expansion) valve which has a supply channel made in the body of the piston, a plate covering an outlet aperture of the supply channel from the side of the expansion (compression) chamber, and an elastic element, the action of the elastic force of which on the plate is directed toward the piston, **characterized** in that at least one through aperture in the piston is covered by a movable gate, has a longitudinal structural element, at least one longitudinal guide is made on a section of the surface of that element which coincides with the piston stroke, the movable gate is pressed against the longitudinal guide by an elastic element, the transverse profile of the longitudinal guide sets in each point of the piston stroke a position of the movable gate relative to the aperture covered thereby, the flow cross section of the channel, formed by the movable gate and the aperture covered thereby in the position of the piston corresponding to the minimum flow cross section of the compression (expansion) channel when the compression (expansion) valve is completely open, is at the most less than the flow cross section of that same channel in the position of the piston corresponding to the maximum flow cross section of the compression (expansion) channel when the compression (expansion) valve is completely open.

15. A device according to claim 14, characterized in that the guide with which the movable gate interacts is made on the inner surface of the working cylinder of the damper.

16. A device according to claim 14, characterized in that the rod of the damper is made hollow, the guide with which the movable gate interacts is made on the external surface of a pin which is secured on a bottom of the compression chamber and which during forward movement of the piston moves into the cavity of the rod.

17. A device according to claim 15 or claim 16, characterized in that the aperture covered by the movable gate forms a supply channel of the compression (expansion)

valve and has a constant size, which is perpendicular to the direction of movement of the movable gate, the movable gate has a protrusion perpendicular to the direction of its movement, which passes through the aperture closed thereby and together with the piston surface which limits that aperture from the side of the expansion (compression) chamber

5 forms a seat of the compression (expansion) valve.

1. A valve assembly comprising a valve body (1) and a movable gate (2) mounted on the valve body (1) for movement between an open position and a closed position, the valve body (1) having a first chamber (3) and a second chamber (4) separated by a partition (5), the movable gate (2) having a first protrusion (6) and a second protrusion (7) extending from opposite sides of the movable gate (2), the first protrusion (6) being adapted to engage a first seat (8) on the valve body (1) when the movable gate (2) is in the closed position, and the second protrusion (7) being adapted to engage a second seat (9) on the valve body (1) when the movable gate (2) is in the closed position, the first chamber (3) being adapted to receive a fluid from a first source (10) and the second chamber (4) being adapted to receive a fluid from a second source (11), the first chamber (3) and the second chamber (4) being adapted to expand and contract independently of each other.

## ABSTRACT

The present invention is designed for use in the suspension of a vehicle. The invention solves the problem of automatically changing the resistance characteristic of a damper over a wide range, depending on the amplitude of the unevenness of a road surface. The invention makes it possible to reduce the amplitude of oscillations of the sprung mass and to reduce the force acting thereon.

The proposed method consists in that in addition to changing the flow cross section of a channel which couples the cavities of the damper, depending on the difference in the pressure between those cavities, the movement of the damper piston is converted into displacement of a part of the damper, the position of which part affects the size of the flow cross section of the channel. Wherein each position of the piston sets in accordance therewith the position of that part and the size of the flow cross section of the channel which corresponds to a constant pressure difference.

The method may be carried out using a damper which has a movable gate mounted on the piston, the movable gate covering a constant restrictor, or a supply channel of a valve, or a channel through which the pressure difference acts on a closing element of the valve. The damper has an element on which a helical guide (or a straight guide with a variable depth of the profile) is made along the whole stroke of the piston. During movement of the piston the movable gate, interacting with a guide, effects a turn (or movement along the radius of the piston) and changes the corresponding cross section.

The method may be carried out by means of a damper, which has the aforesaid helical guide and a movable support of an elastic valve element, the support being mounted on the piston. The support is coupled to the piston via another helical guide. During movement of the piston the support, interacting with a first guide, turns and moving along a second guide effects linear displacement relative to the piston and changes the elastic deformation of the elastic element of the valve.

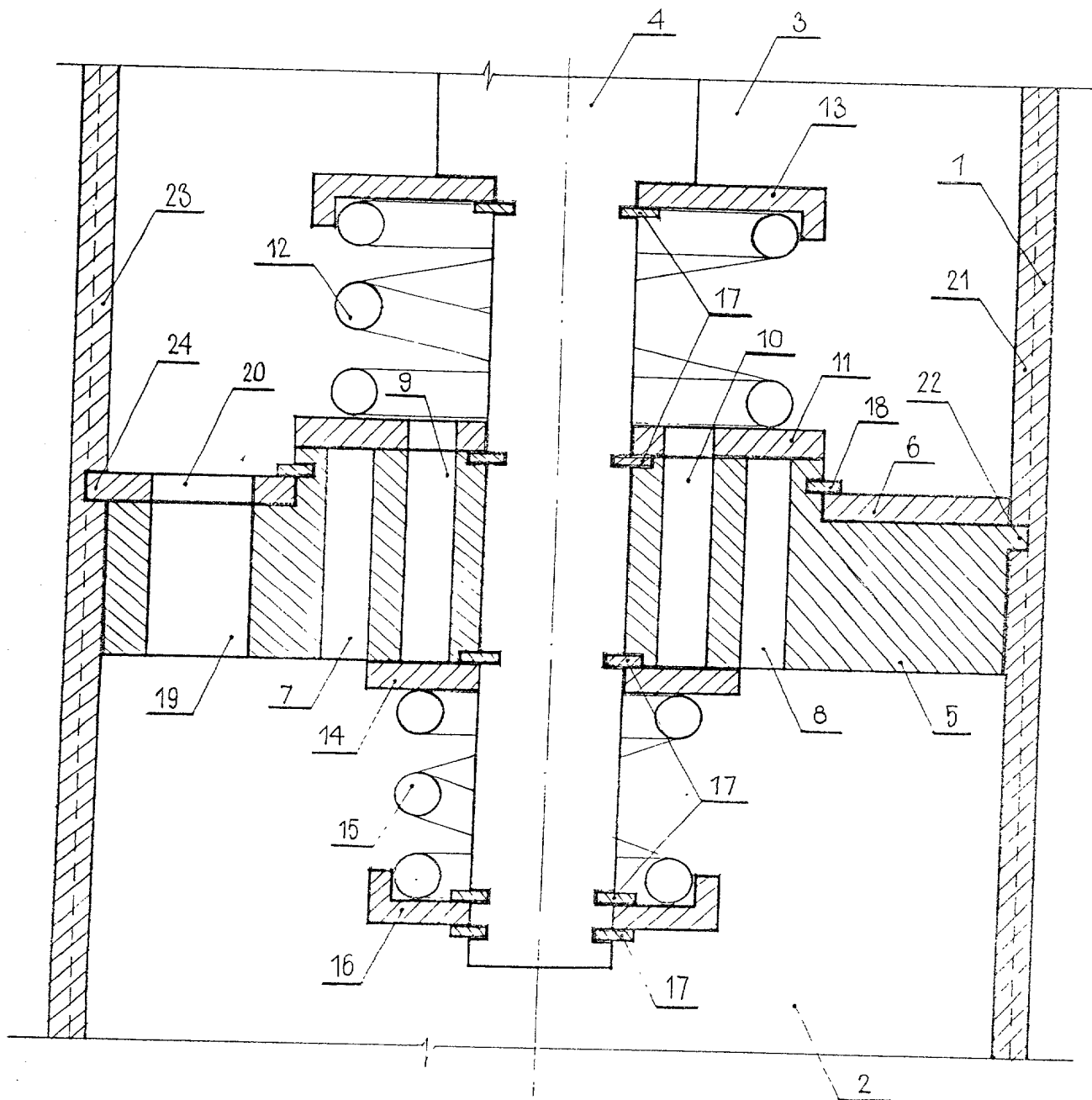
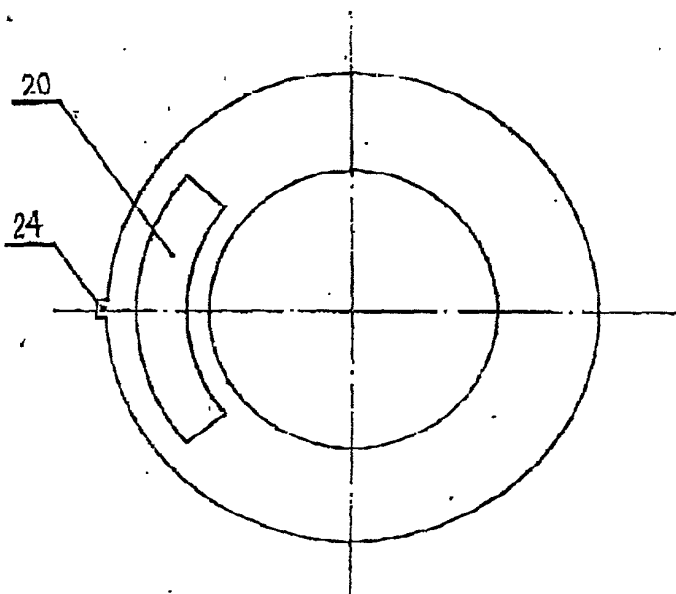


Fig. 1

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Part 6



Part 5

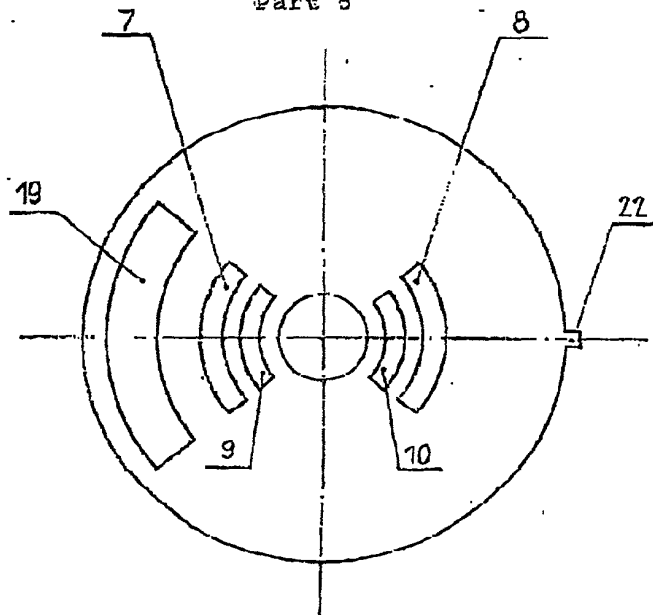


Fig. 2

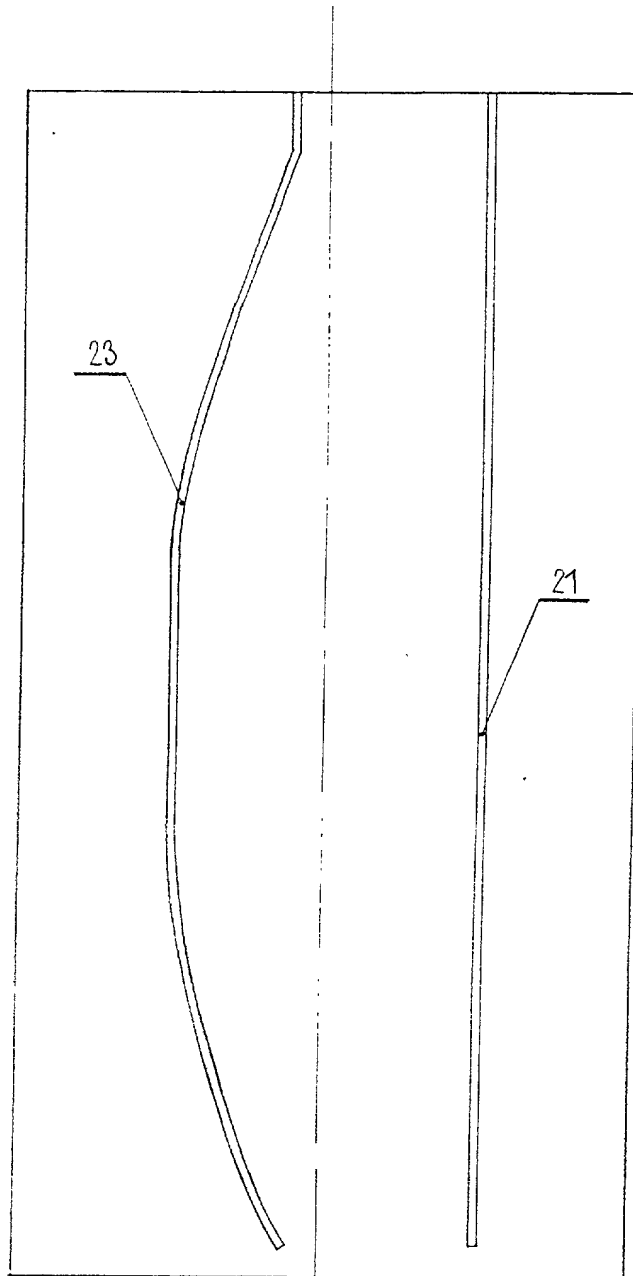


Fig. 3



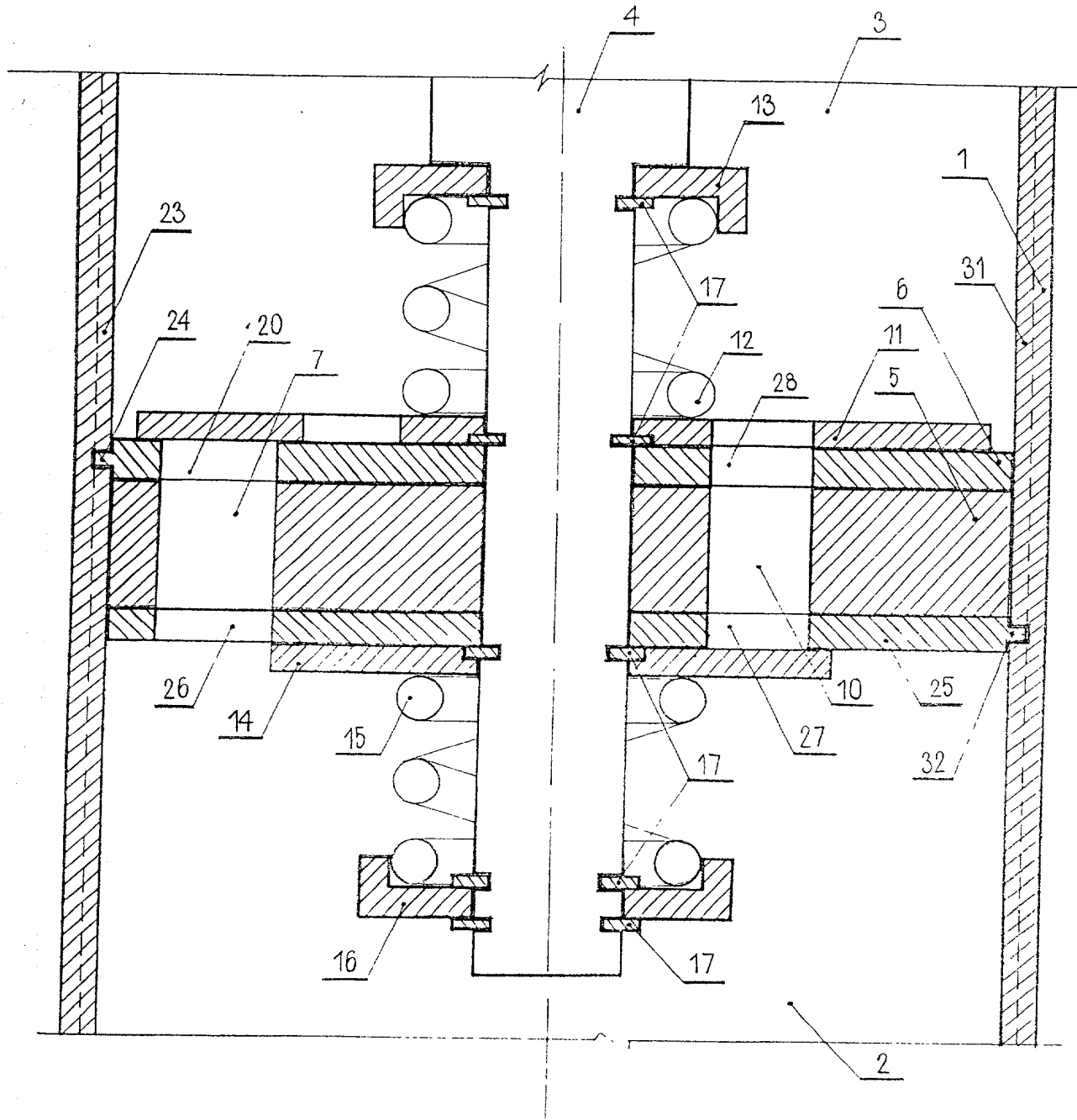
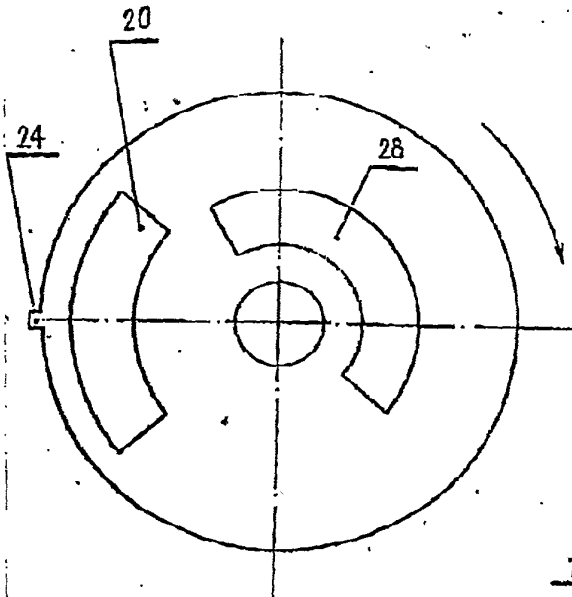


Fig. 4

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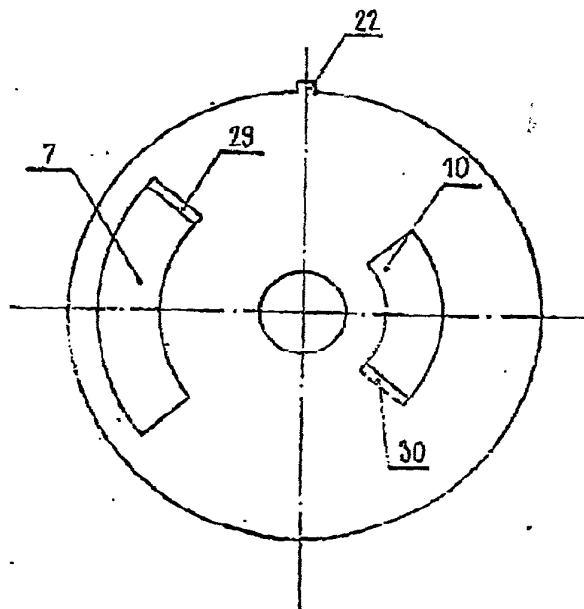
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Part 6

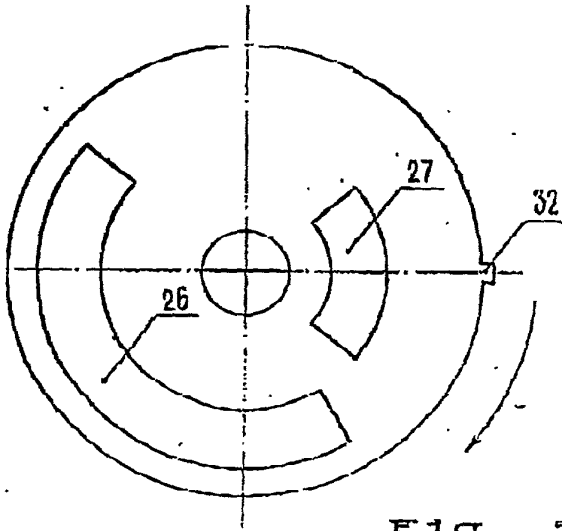


Direction of turn at a reduction  
of the flow section of the supply  
channel of the compression valve

Part 5



Part 25



Direction of turn at a reduction  
of the flow the section of  
the supply channel of the  
expansion valve

Fig. 5

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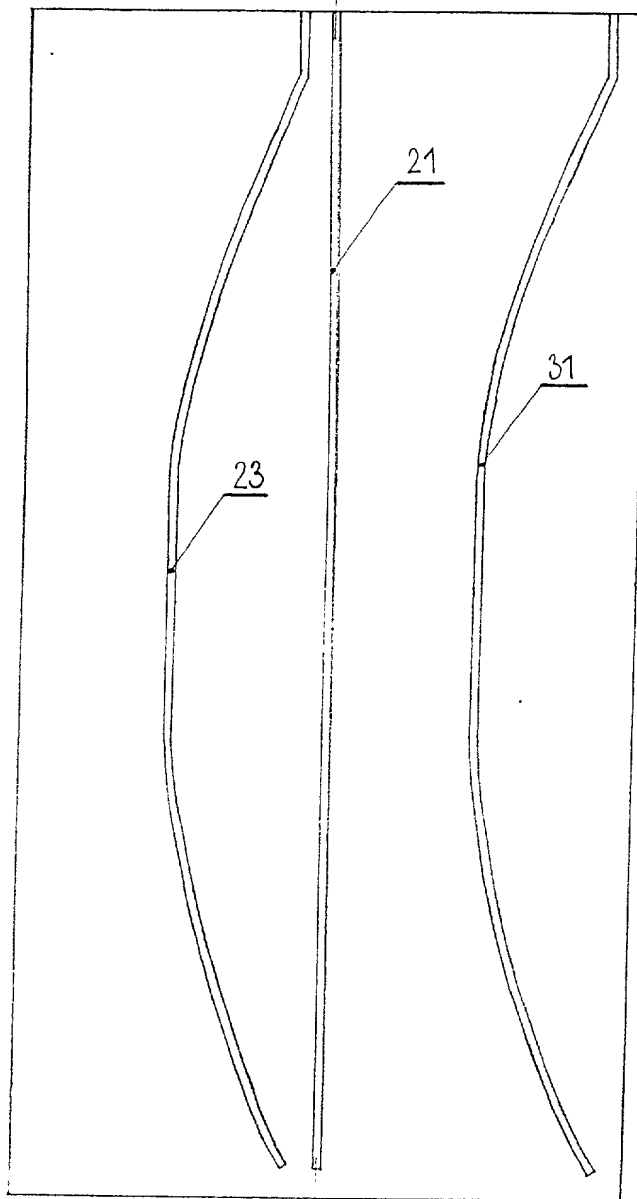


Fig. 6

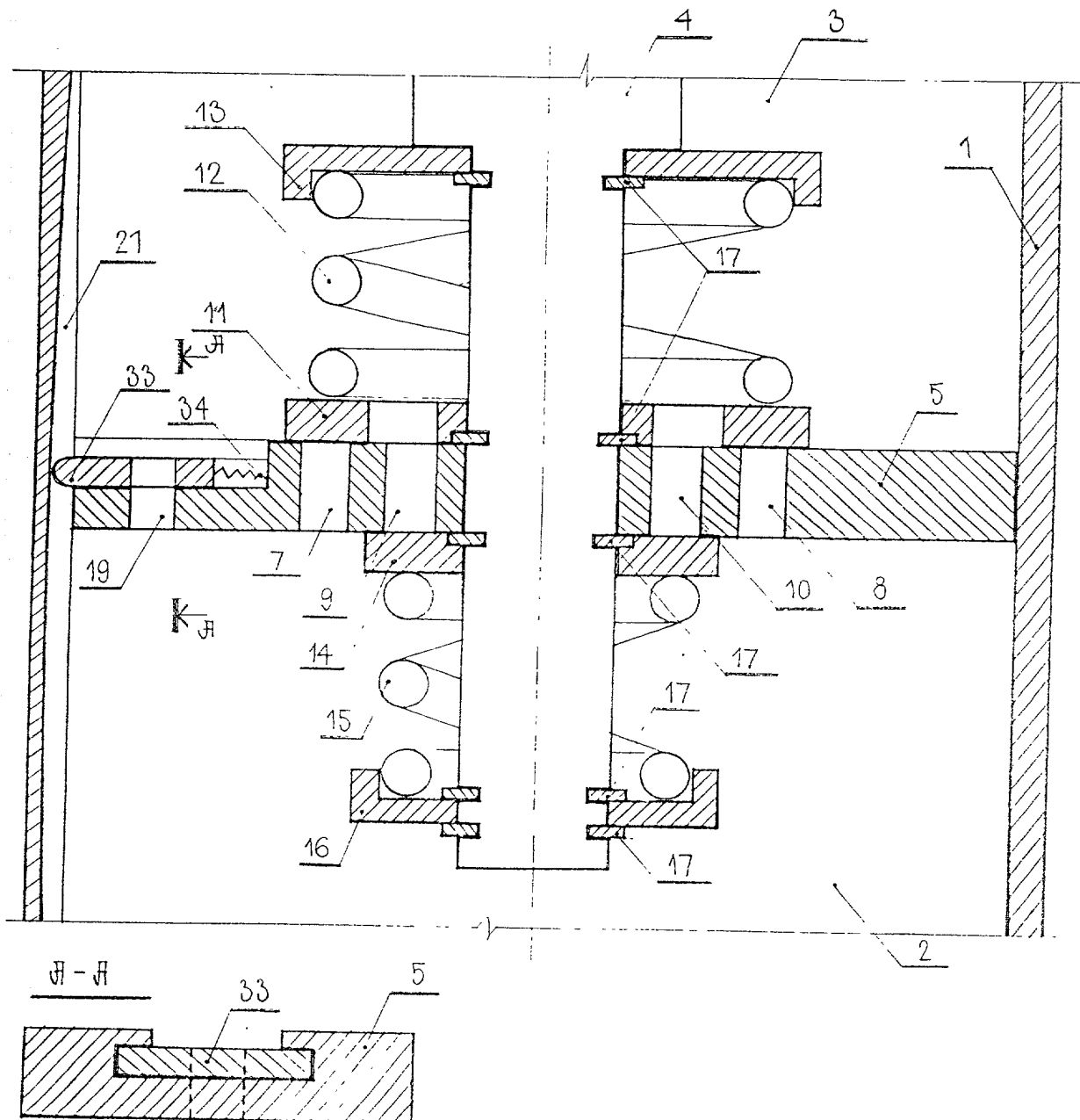


Fig. 7

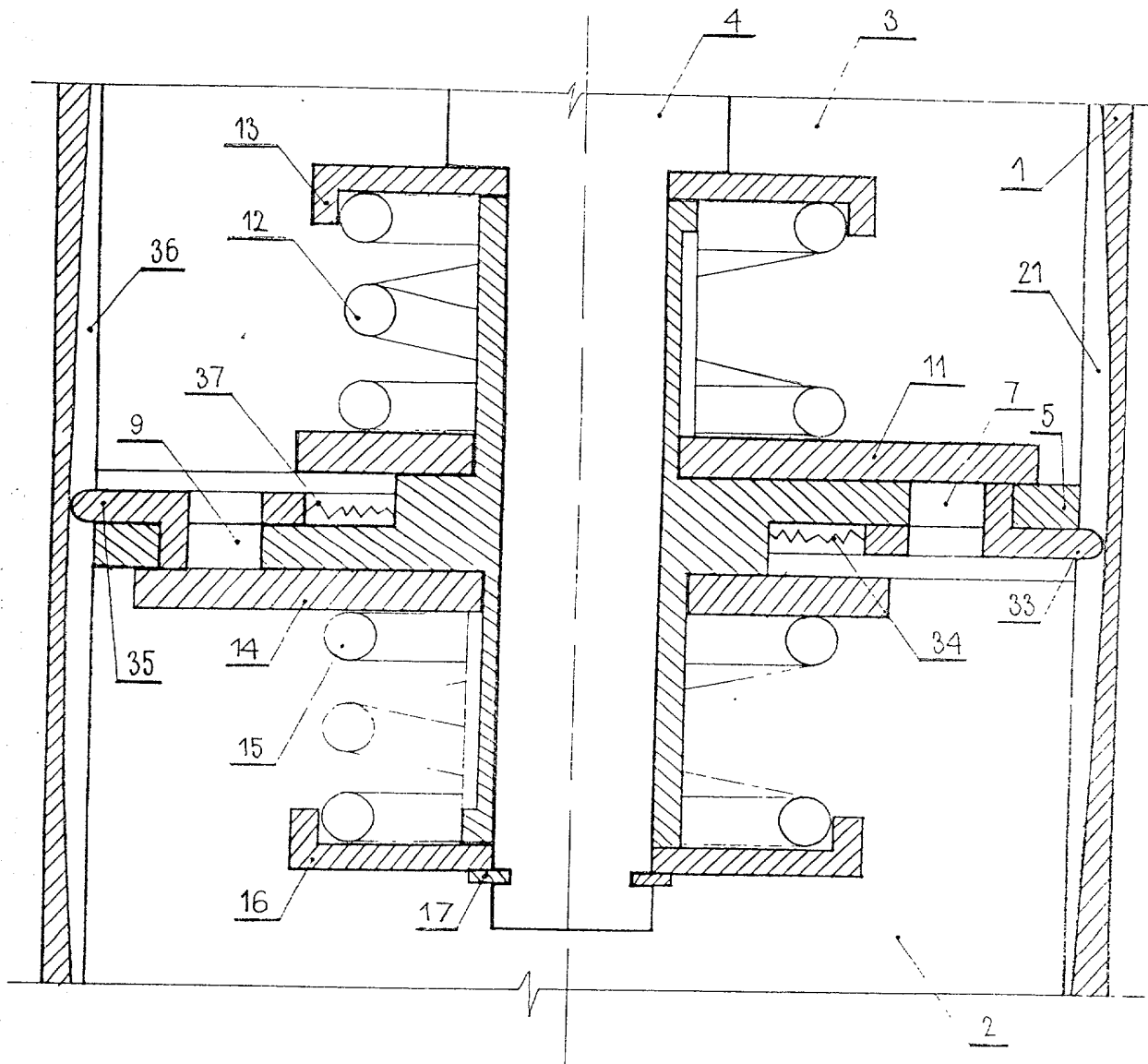


Fig. 8

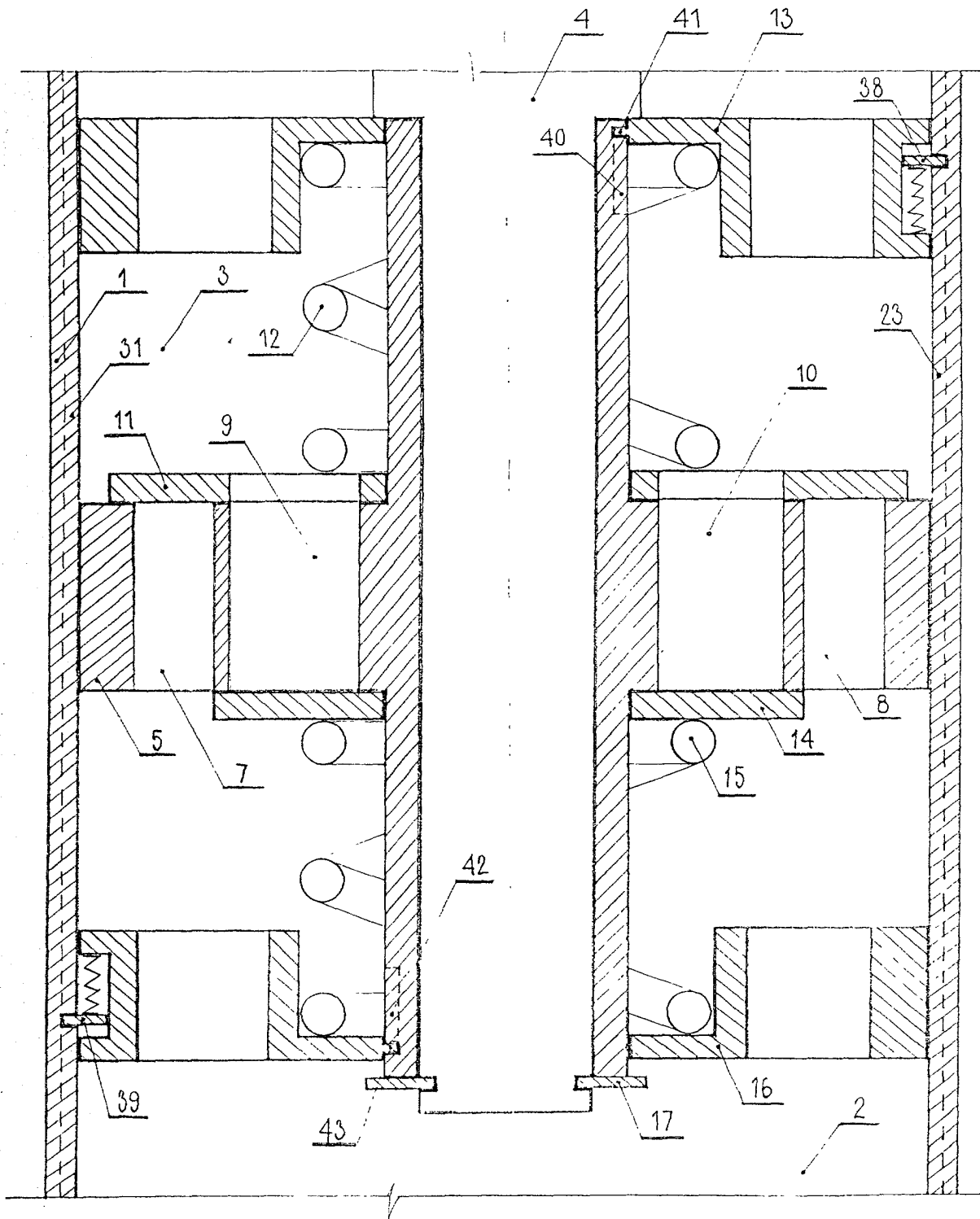
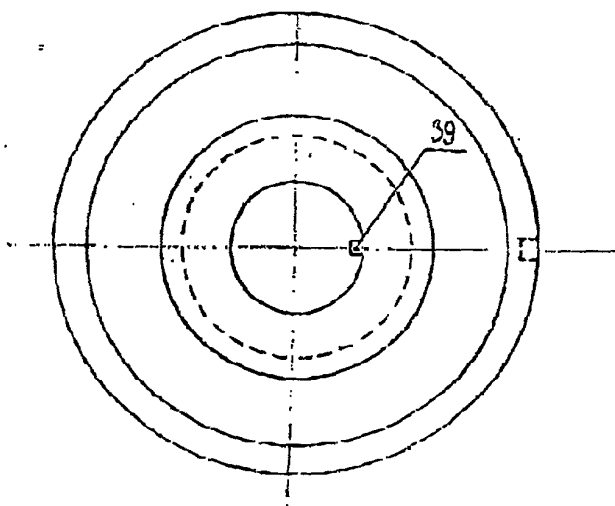


Fig. 9

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Part 13



Part 5

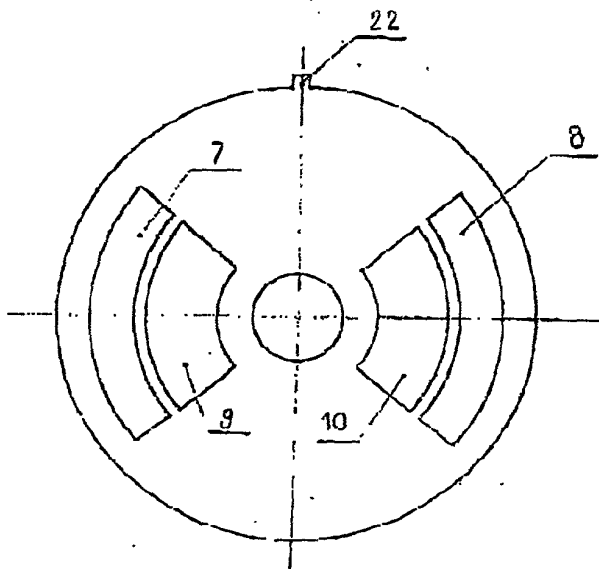


Fig. 10

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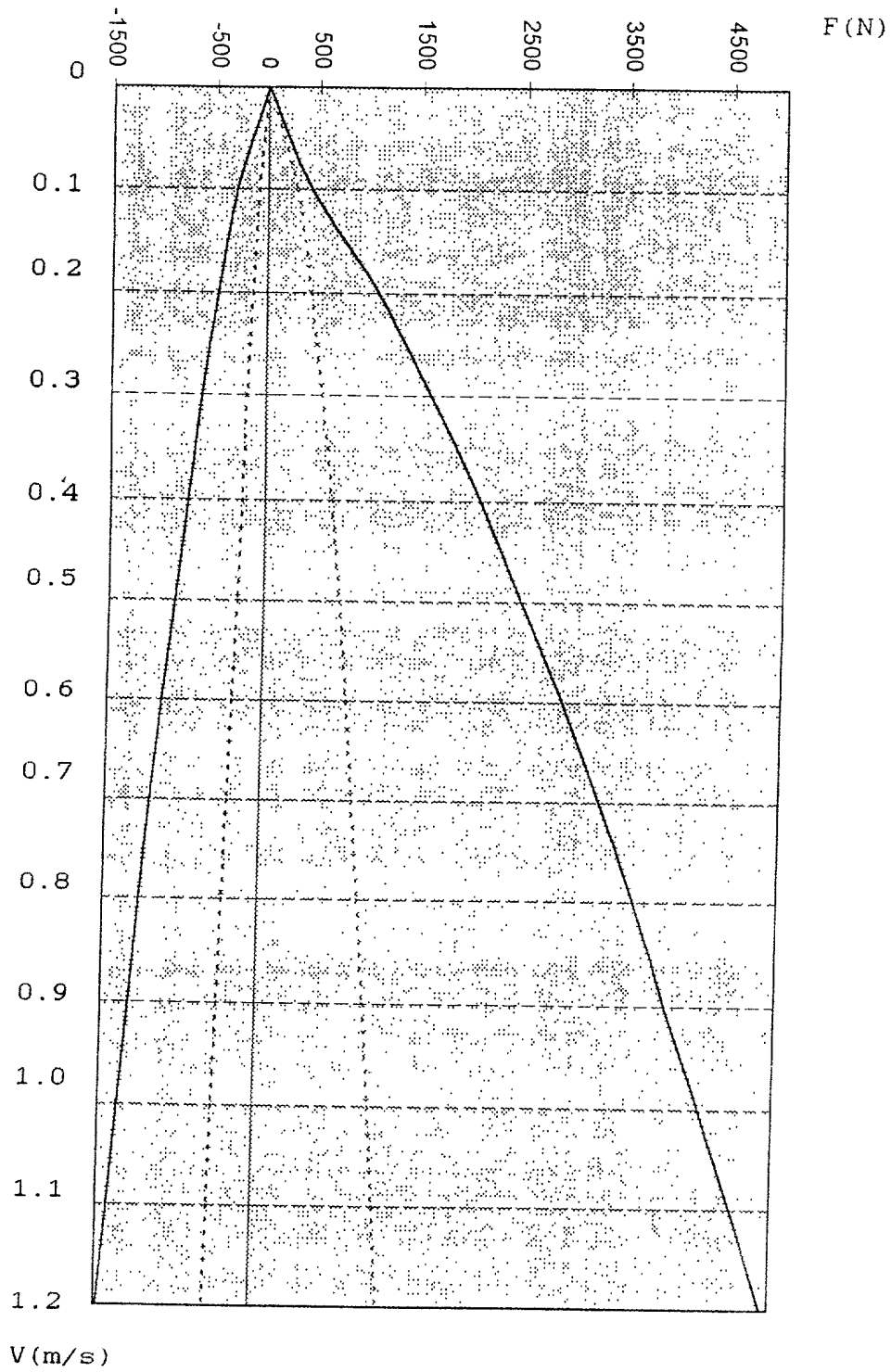


Fig. 11



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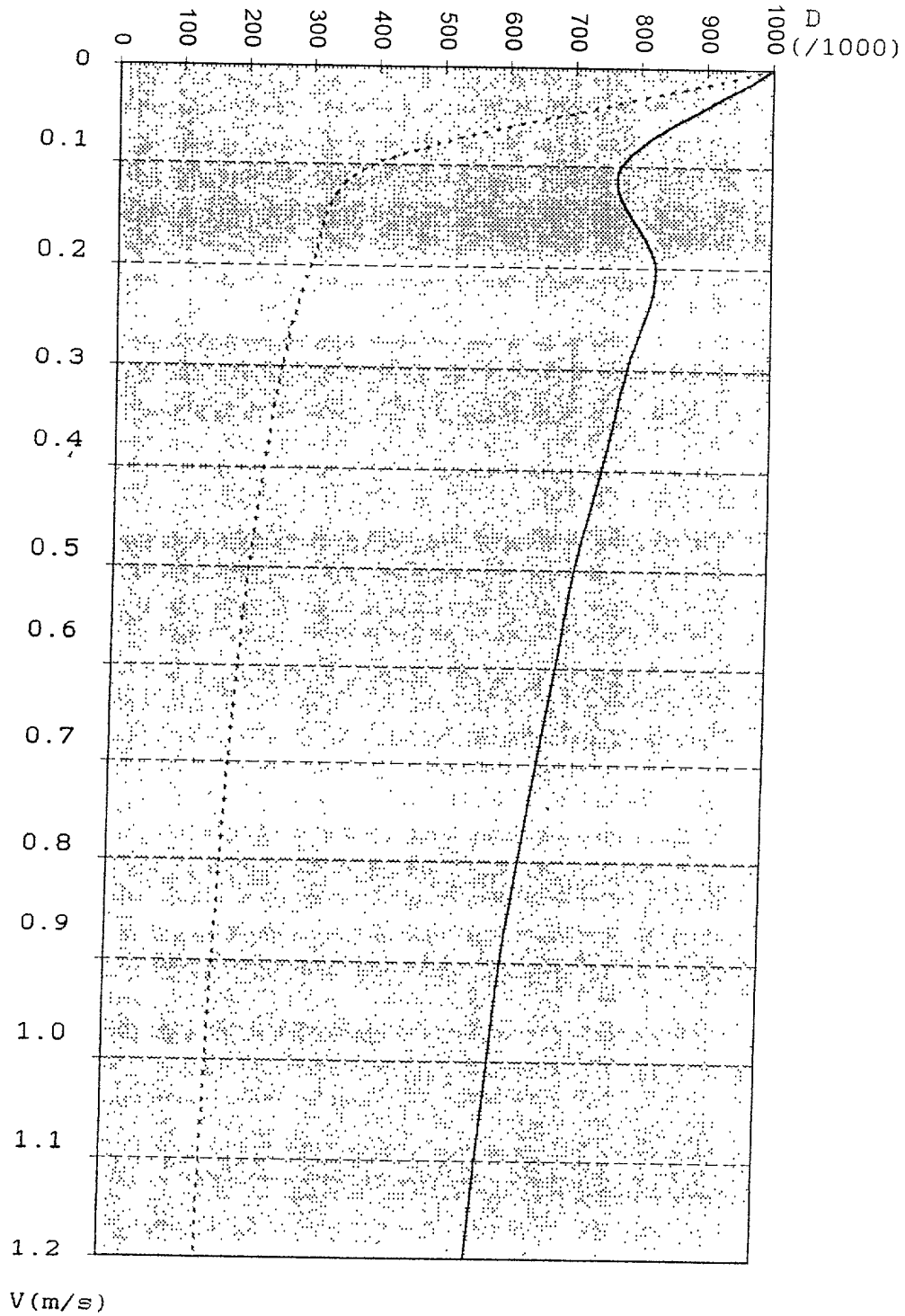


Fig. 12

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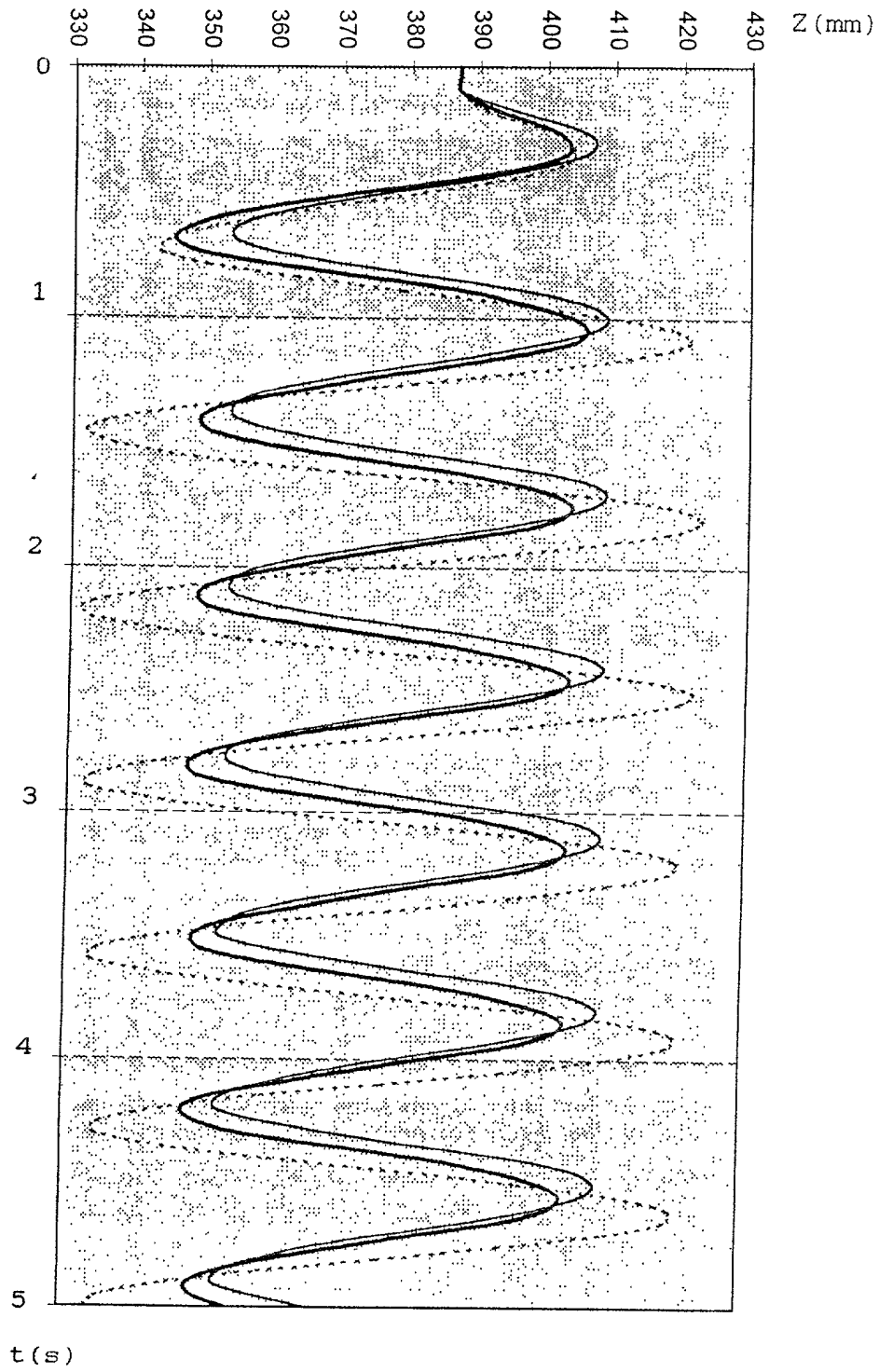


Fig. 13

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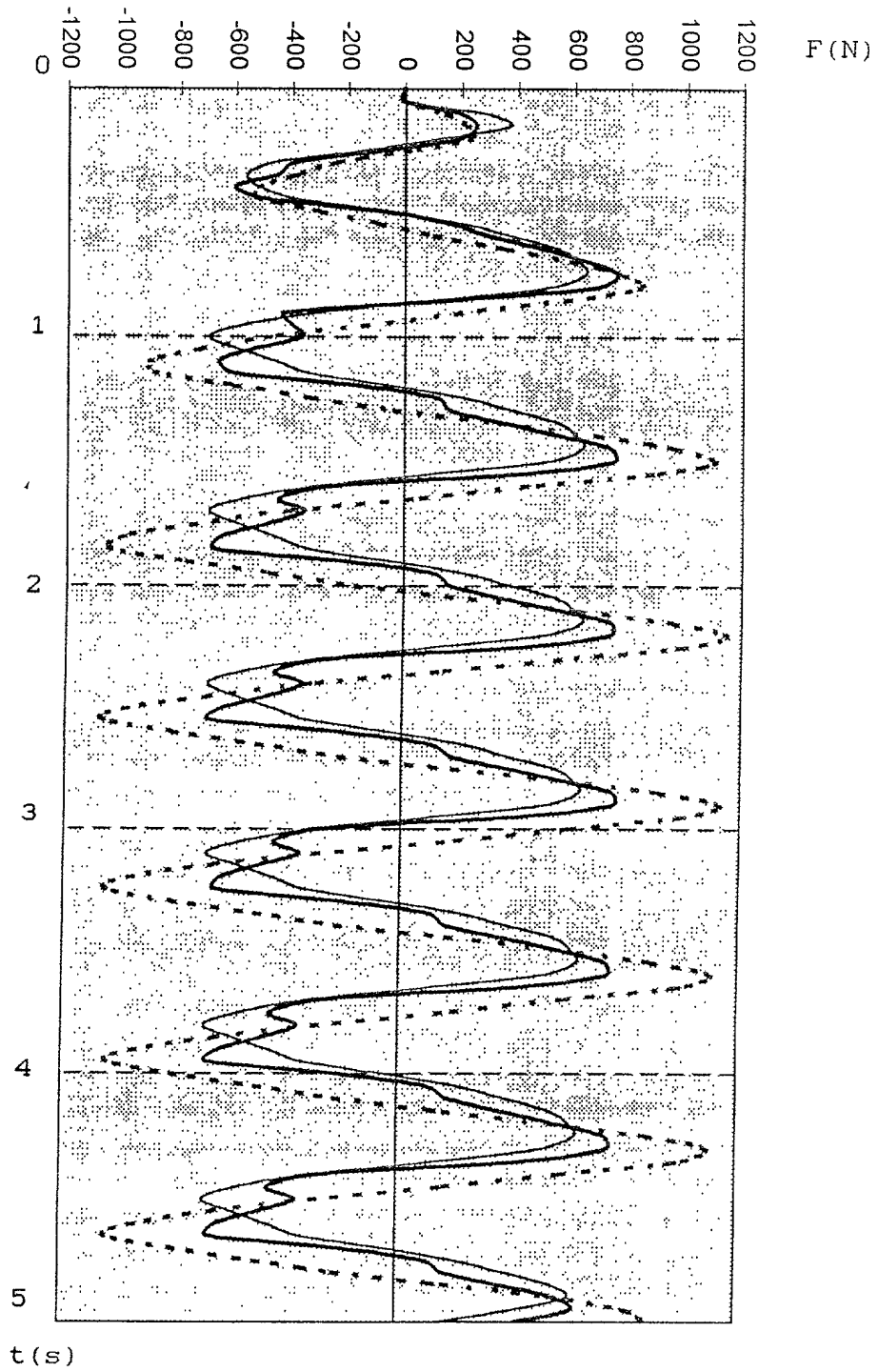


Fig. 14

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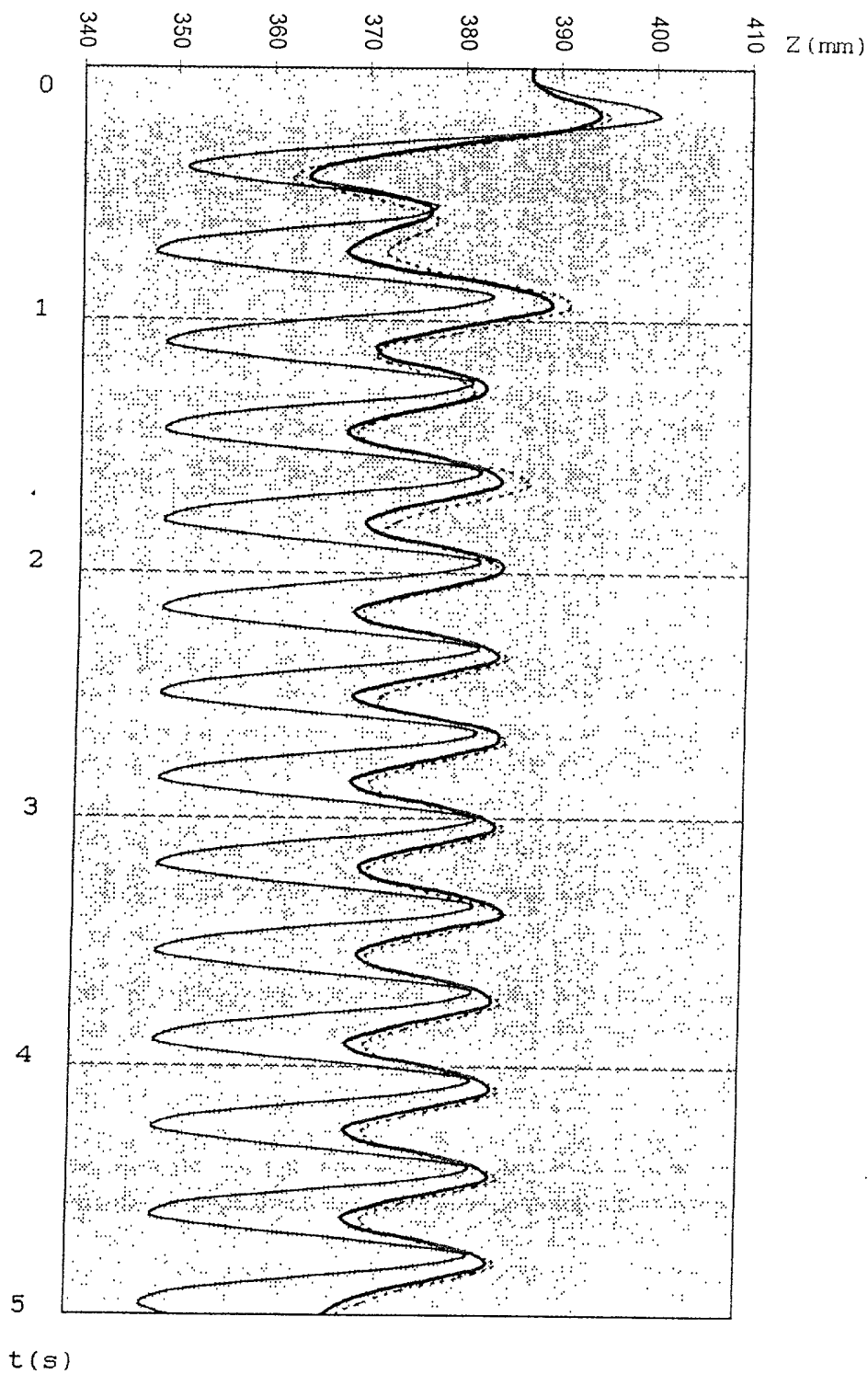


Fig. 15

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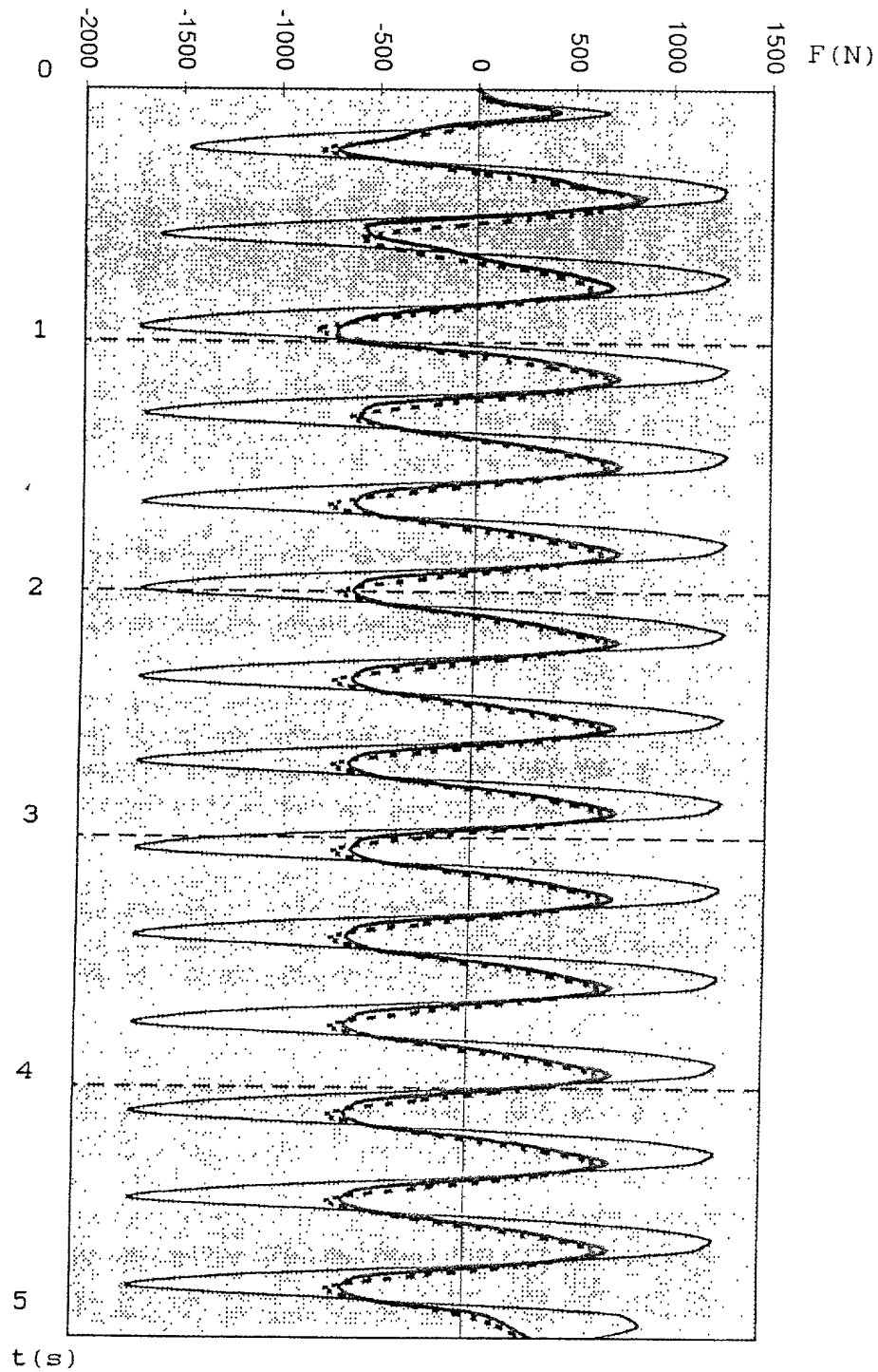


Fig. 16

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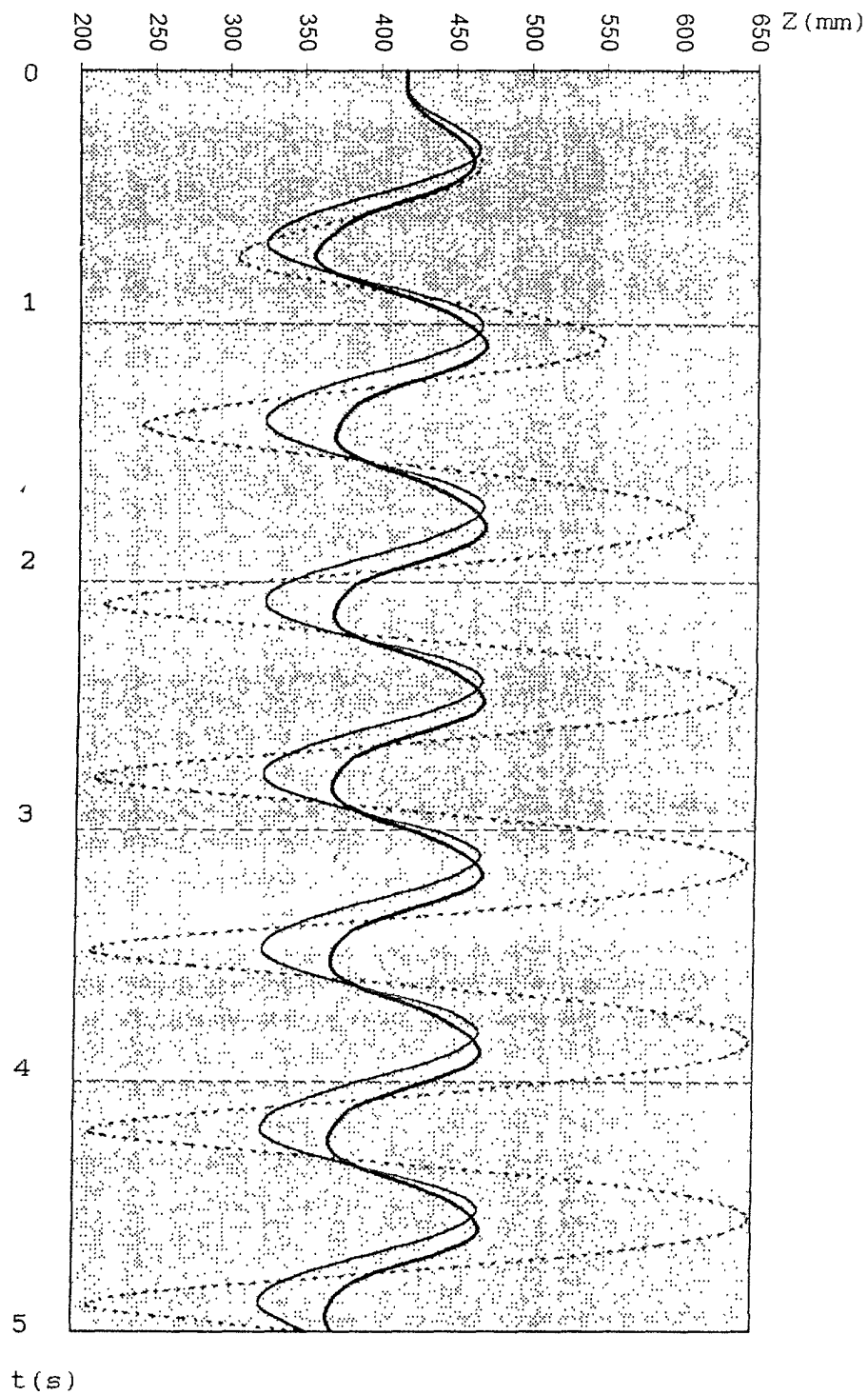


Fig. 17

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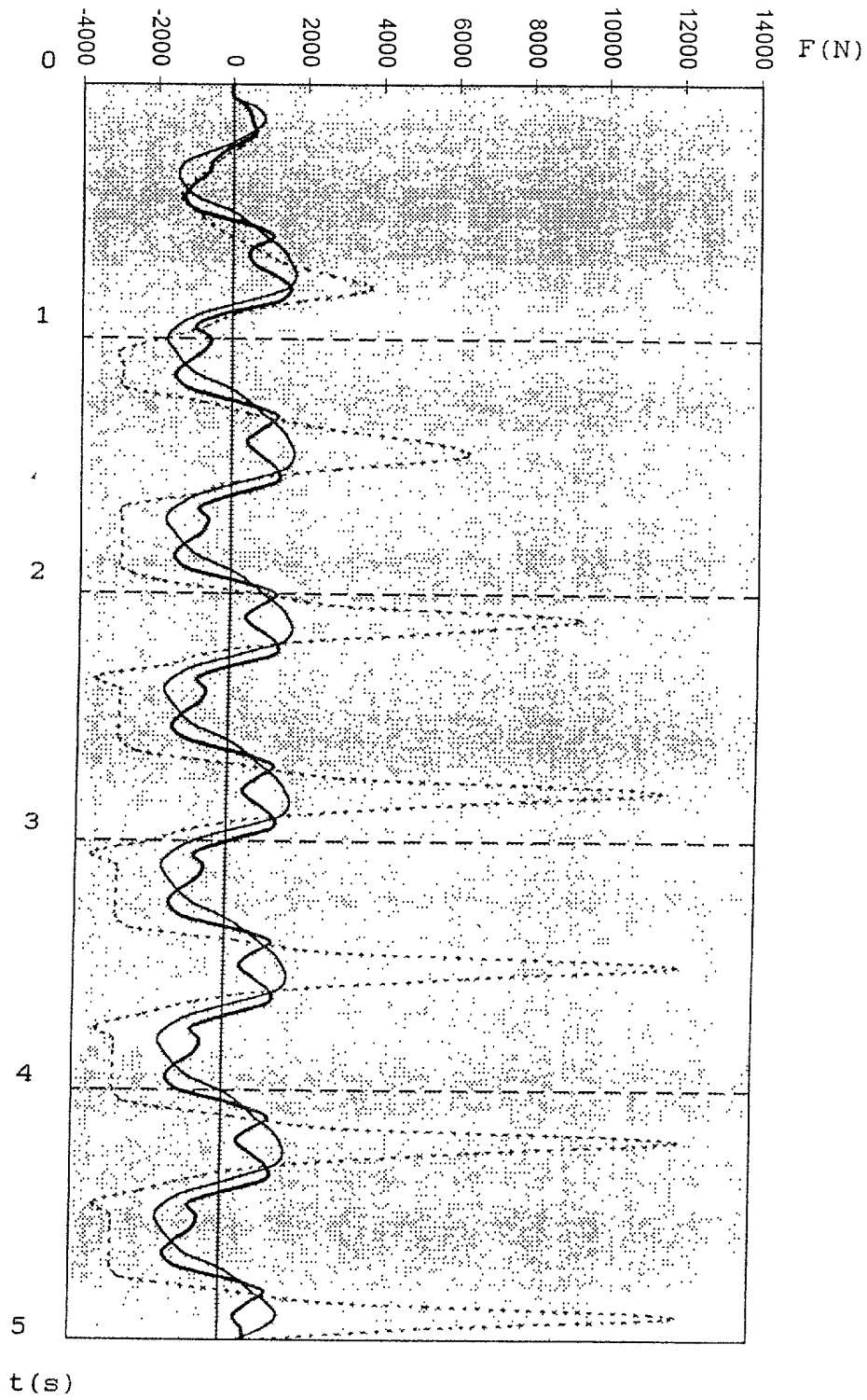


Fig. 18

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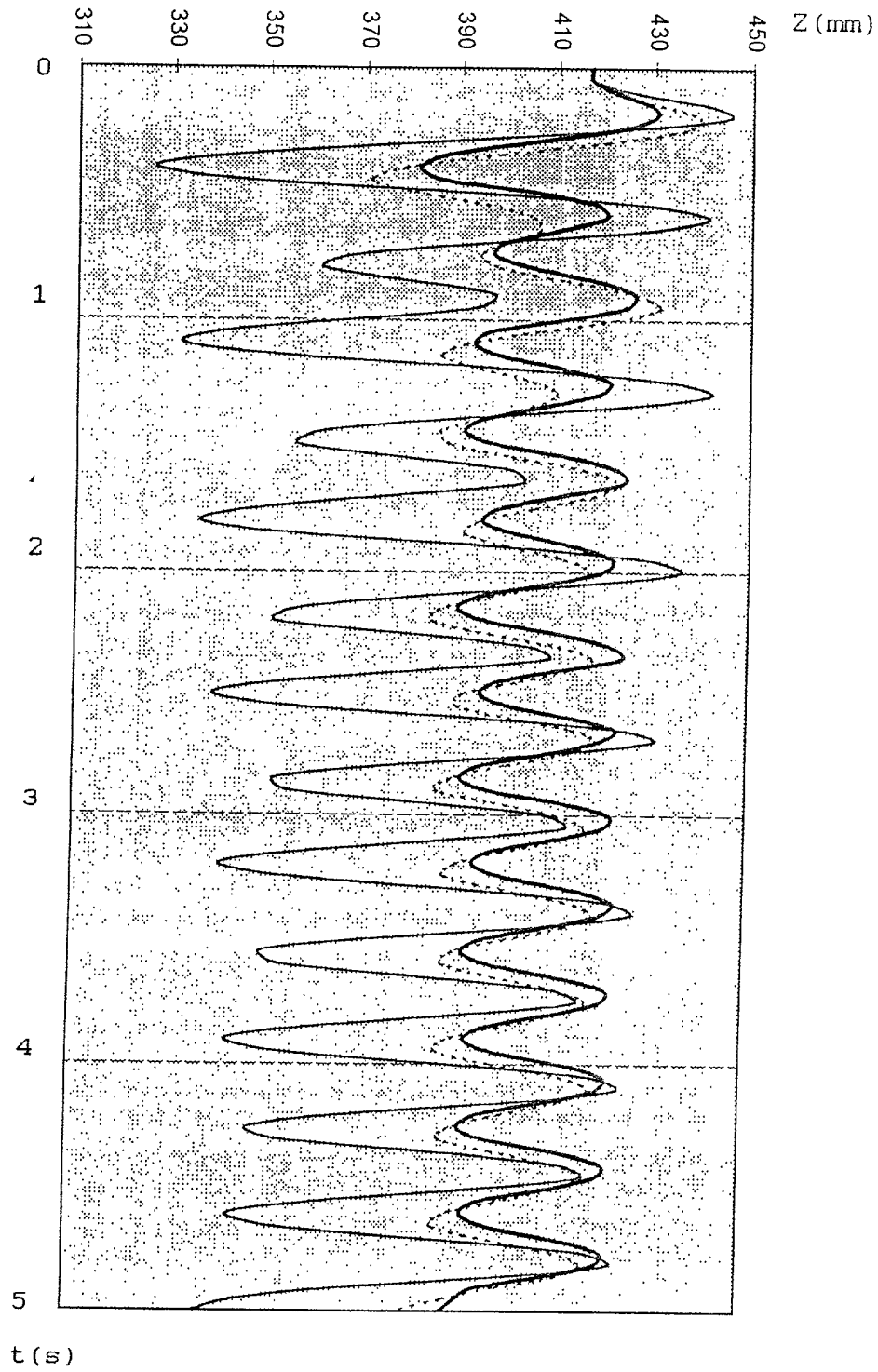


Fig. 19



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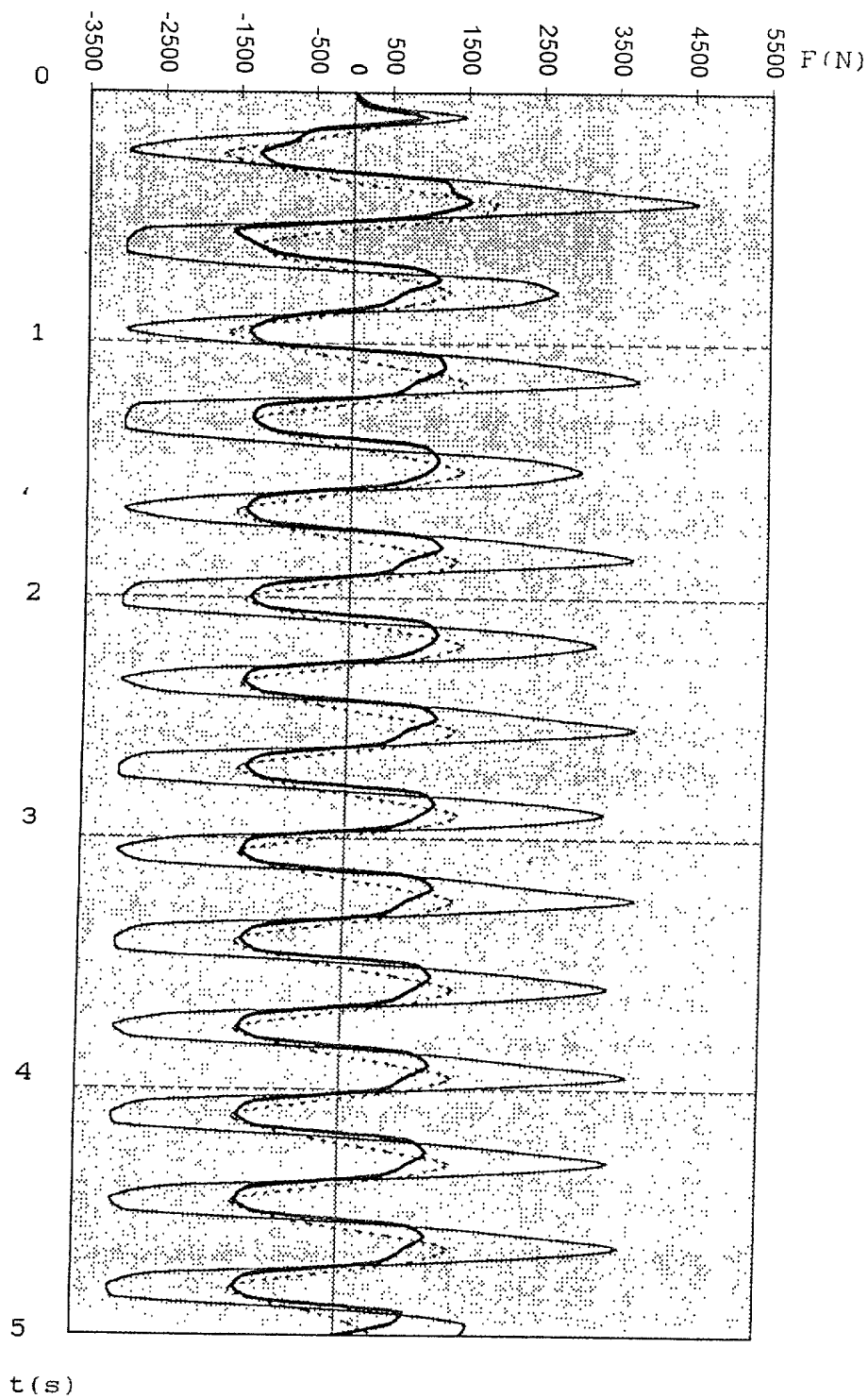


Fig. 20

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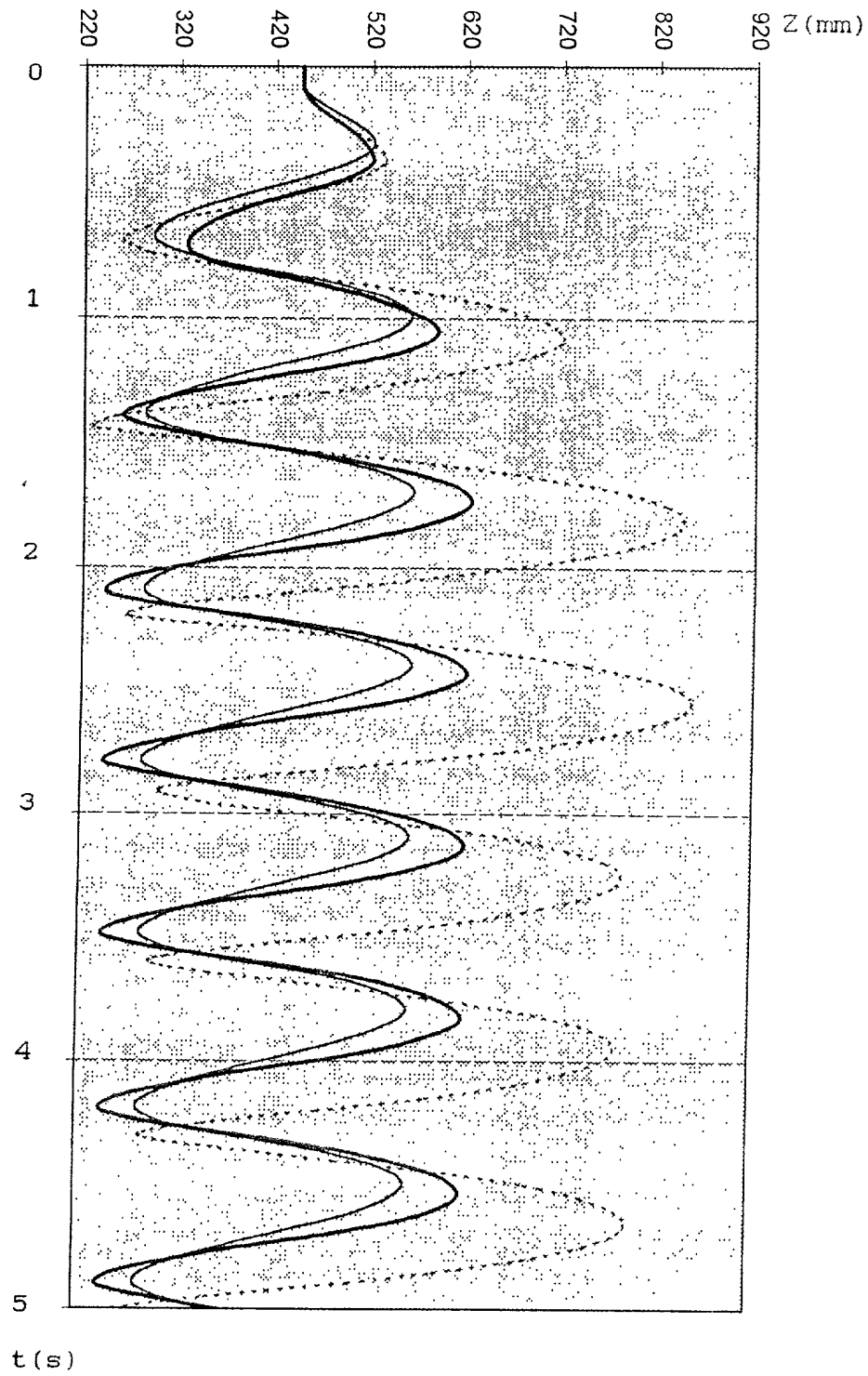


Fig. 21

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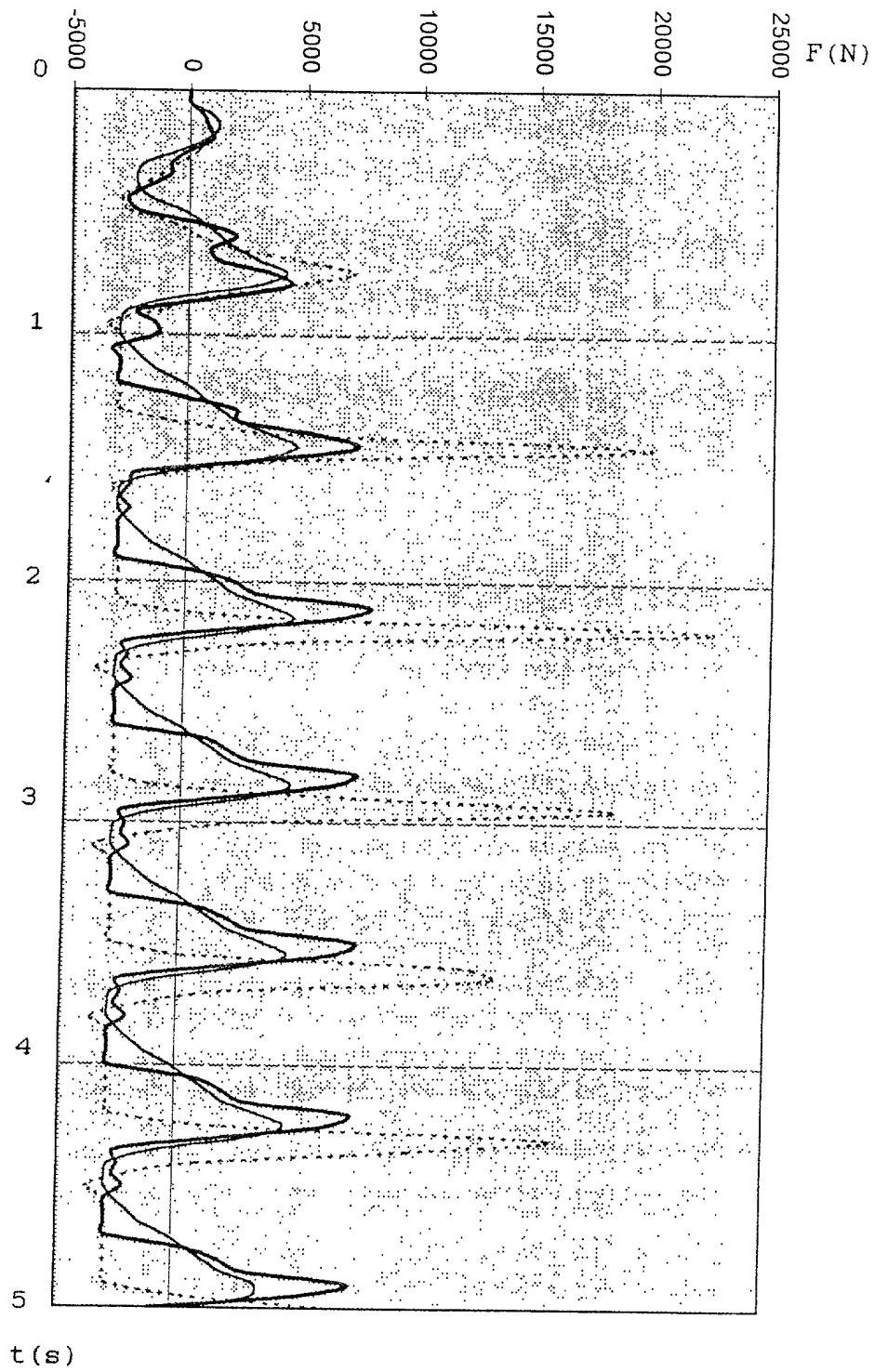


Fig. 22

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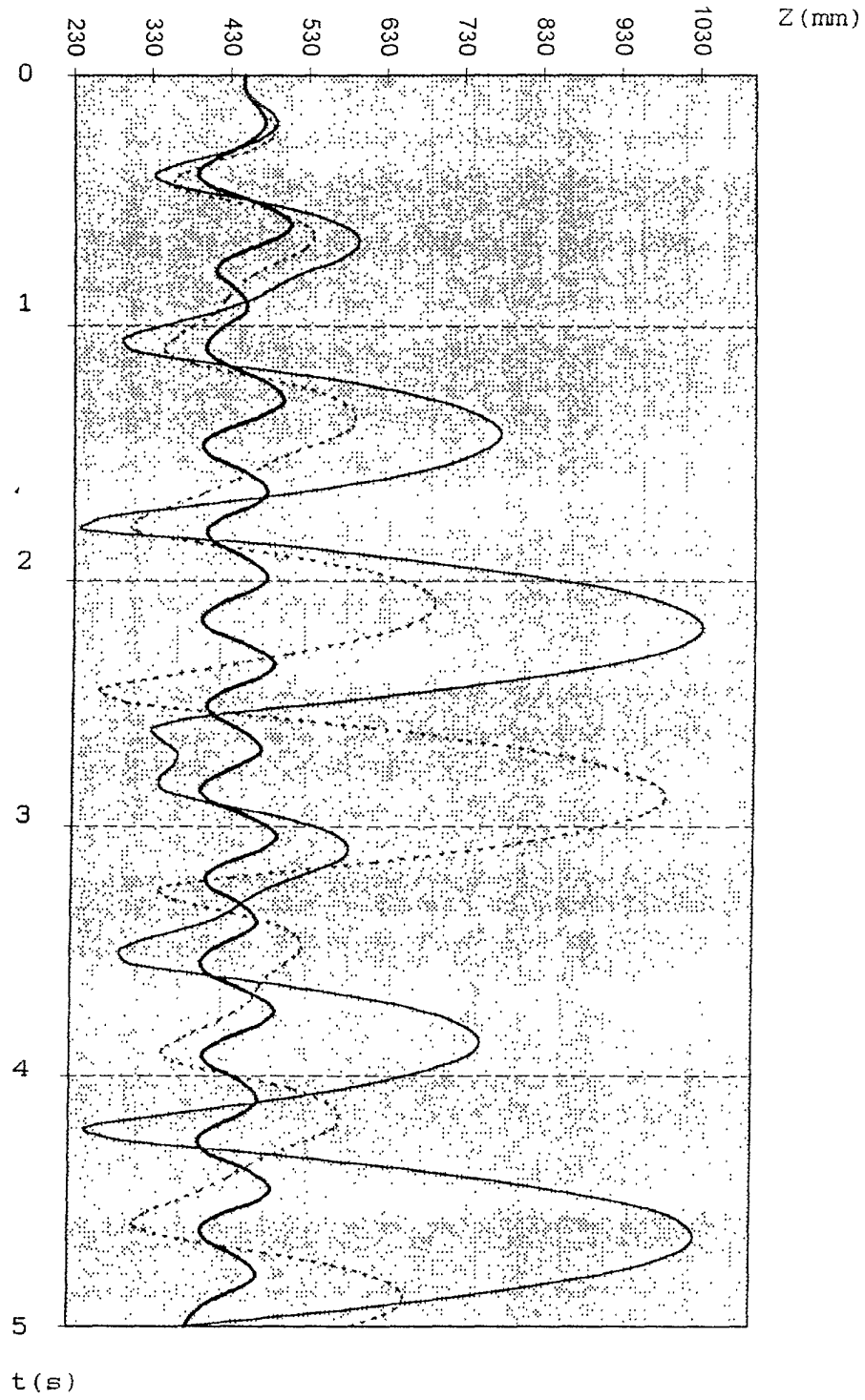


Fig. 23

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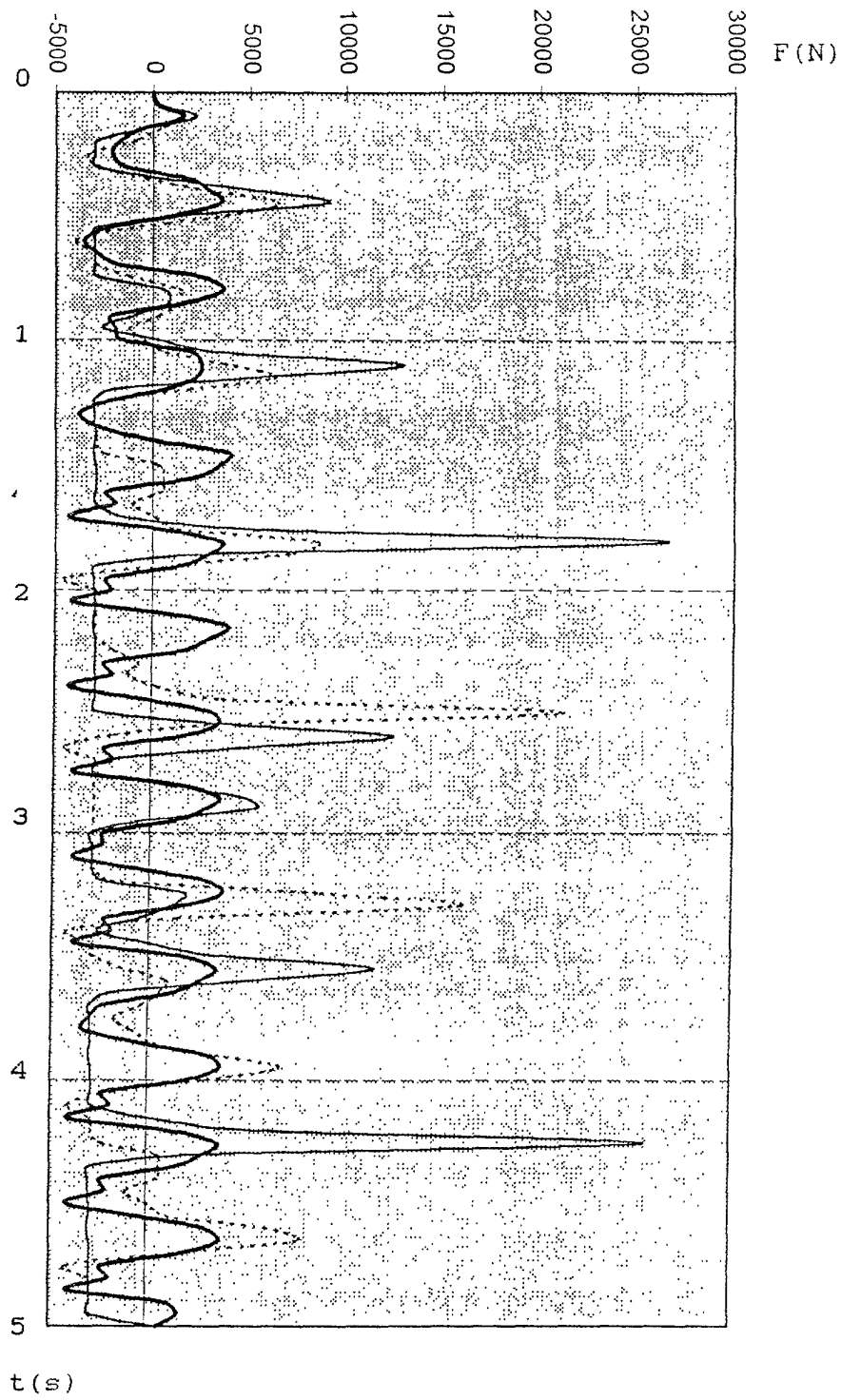


Fig. 24

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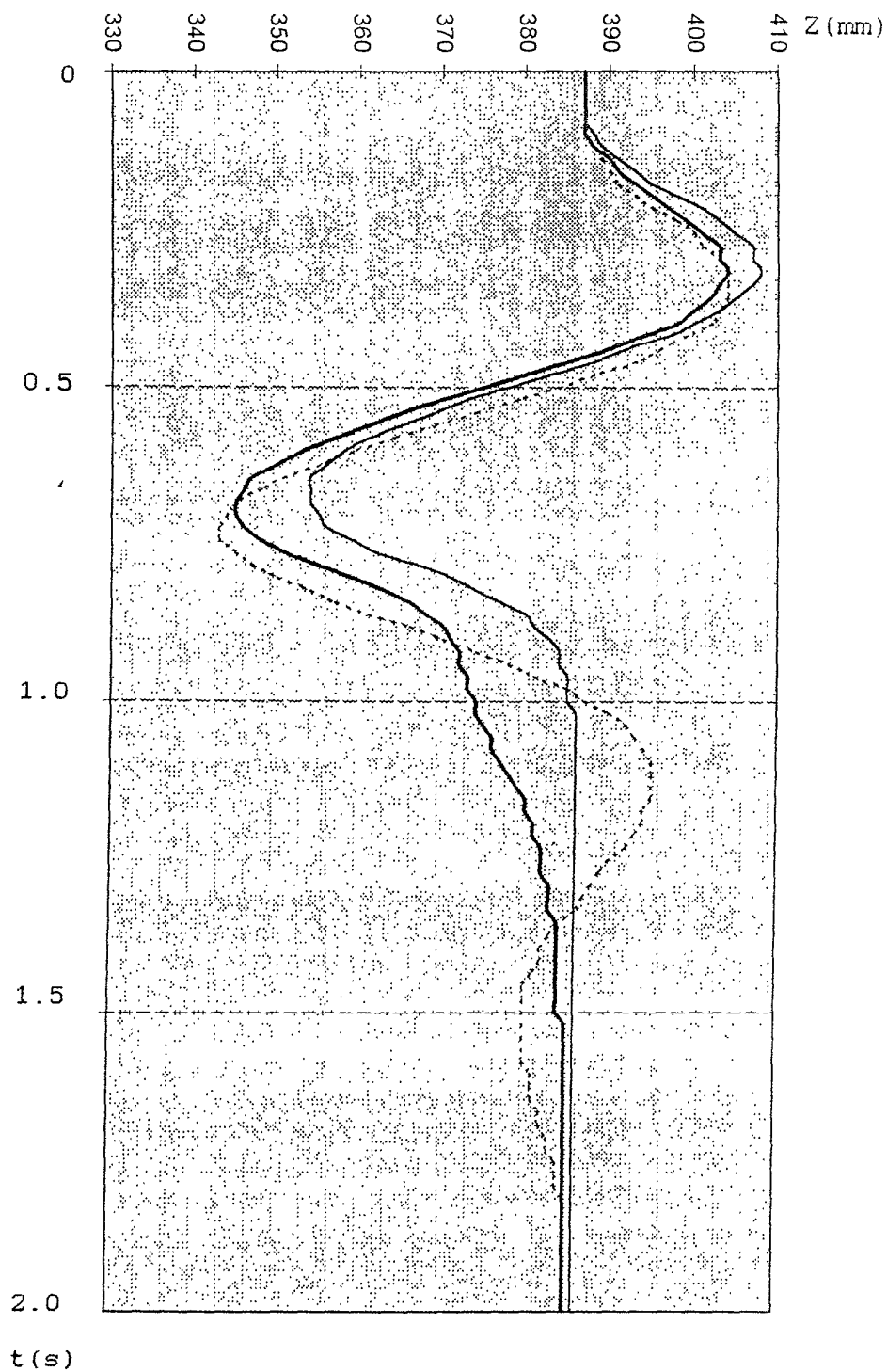


Fig. 25

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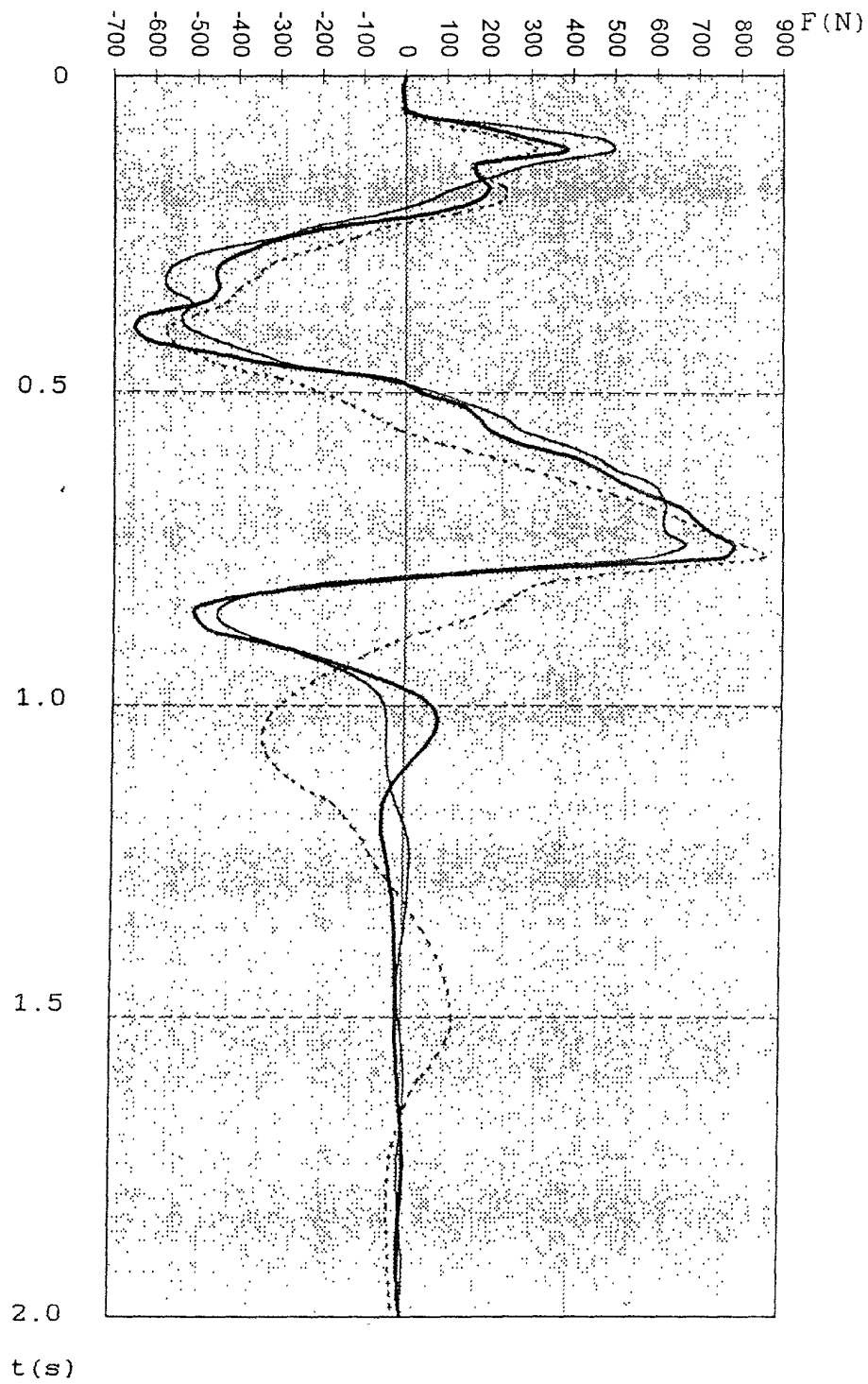


Fig. 26

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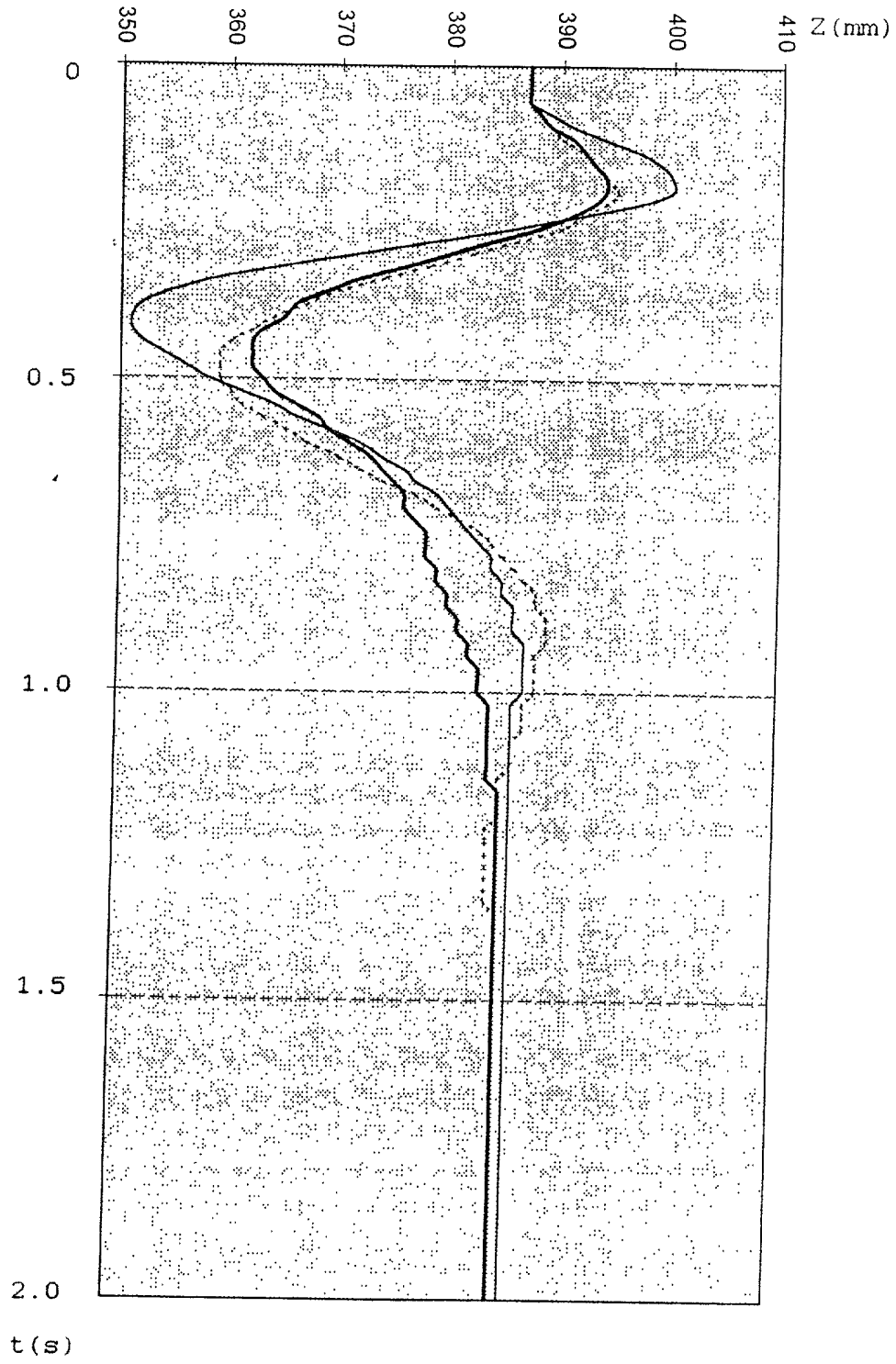


Fig. 27



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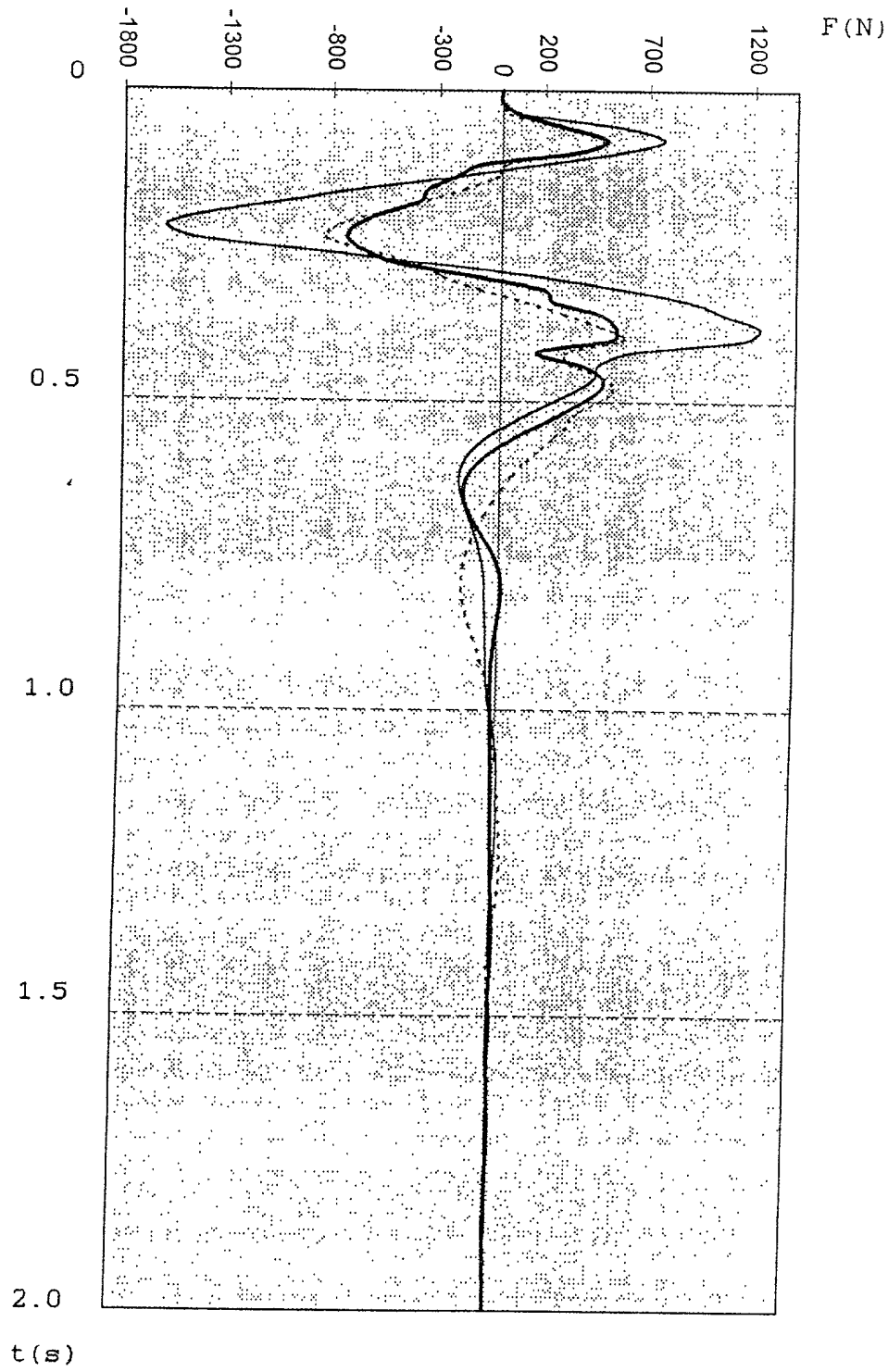


Fig. 28

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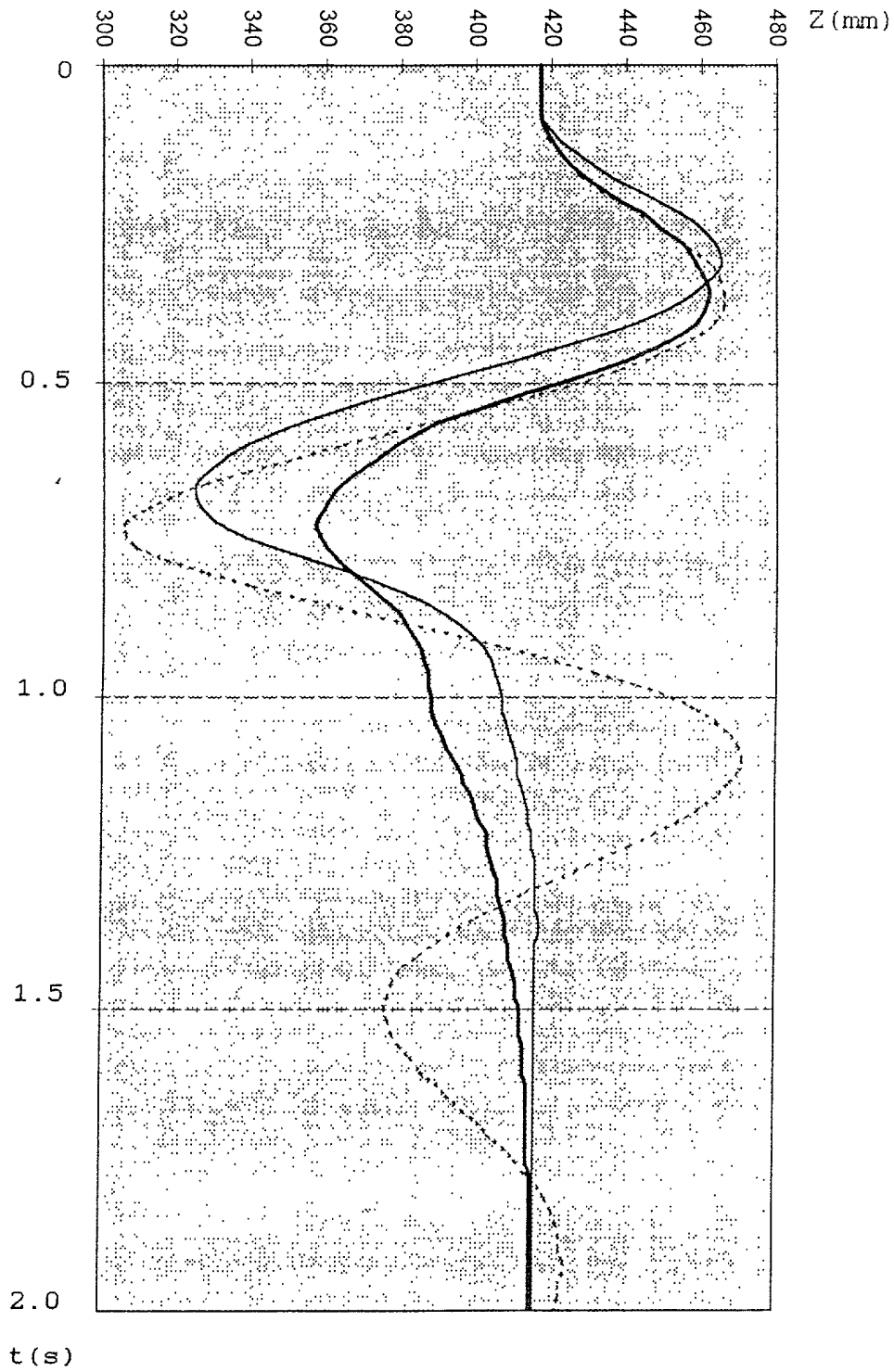


Fig. 29

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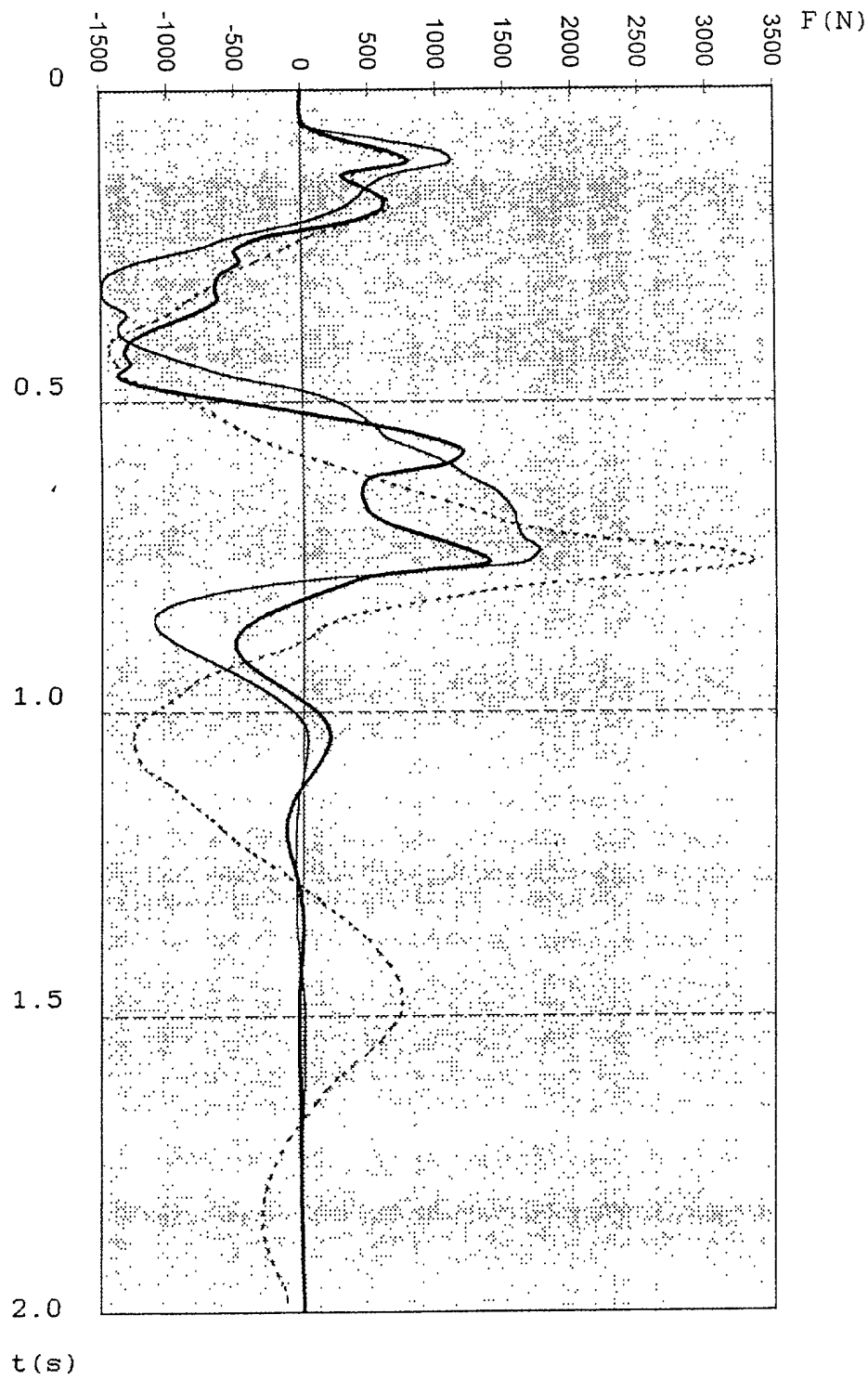


Fig. 30

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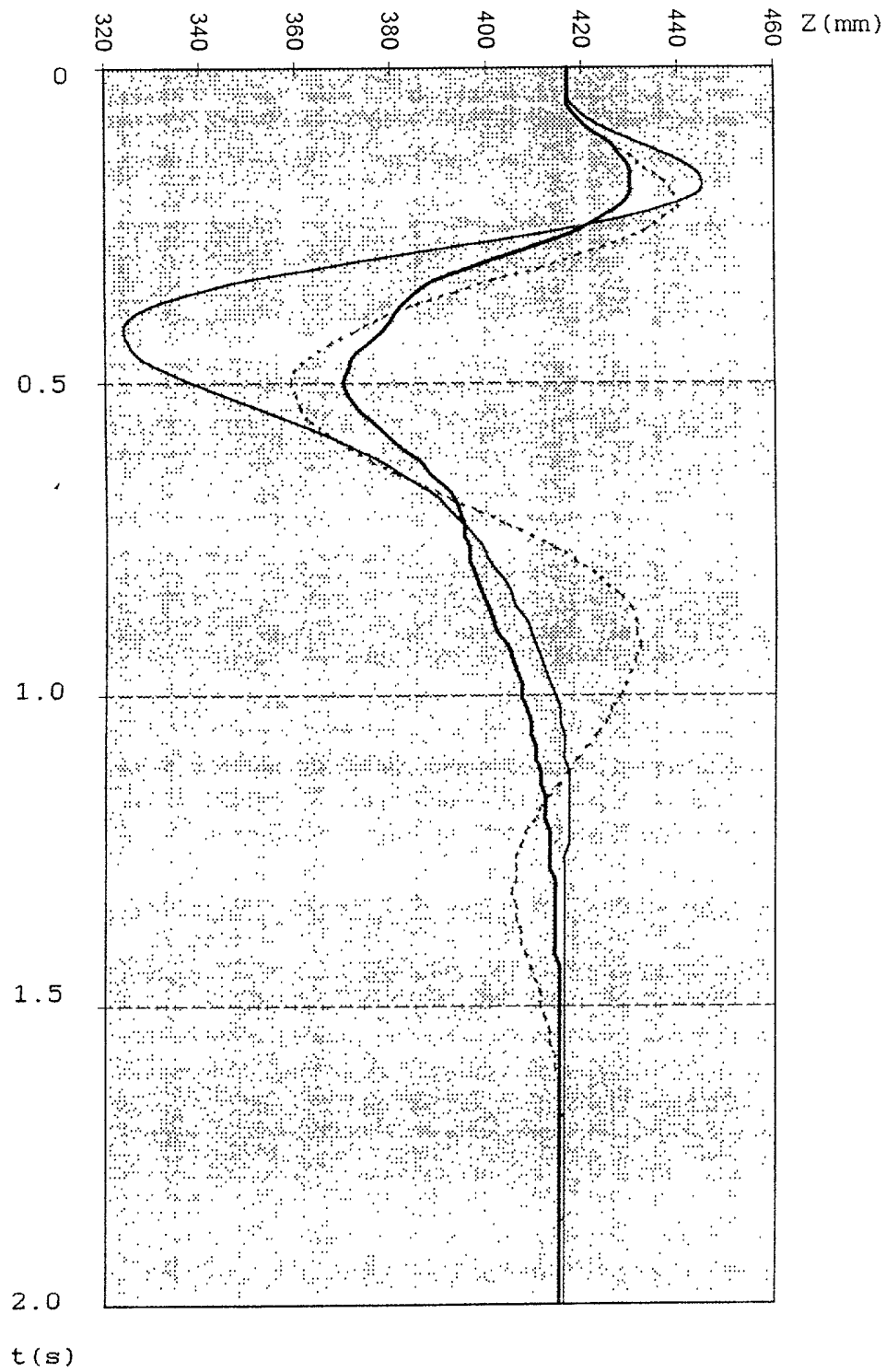


Fig. 31

U 013214-0

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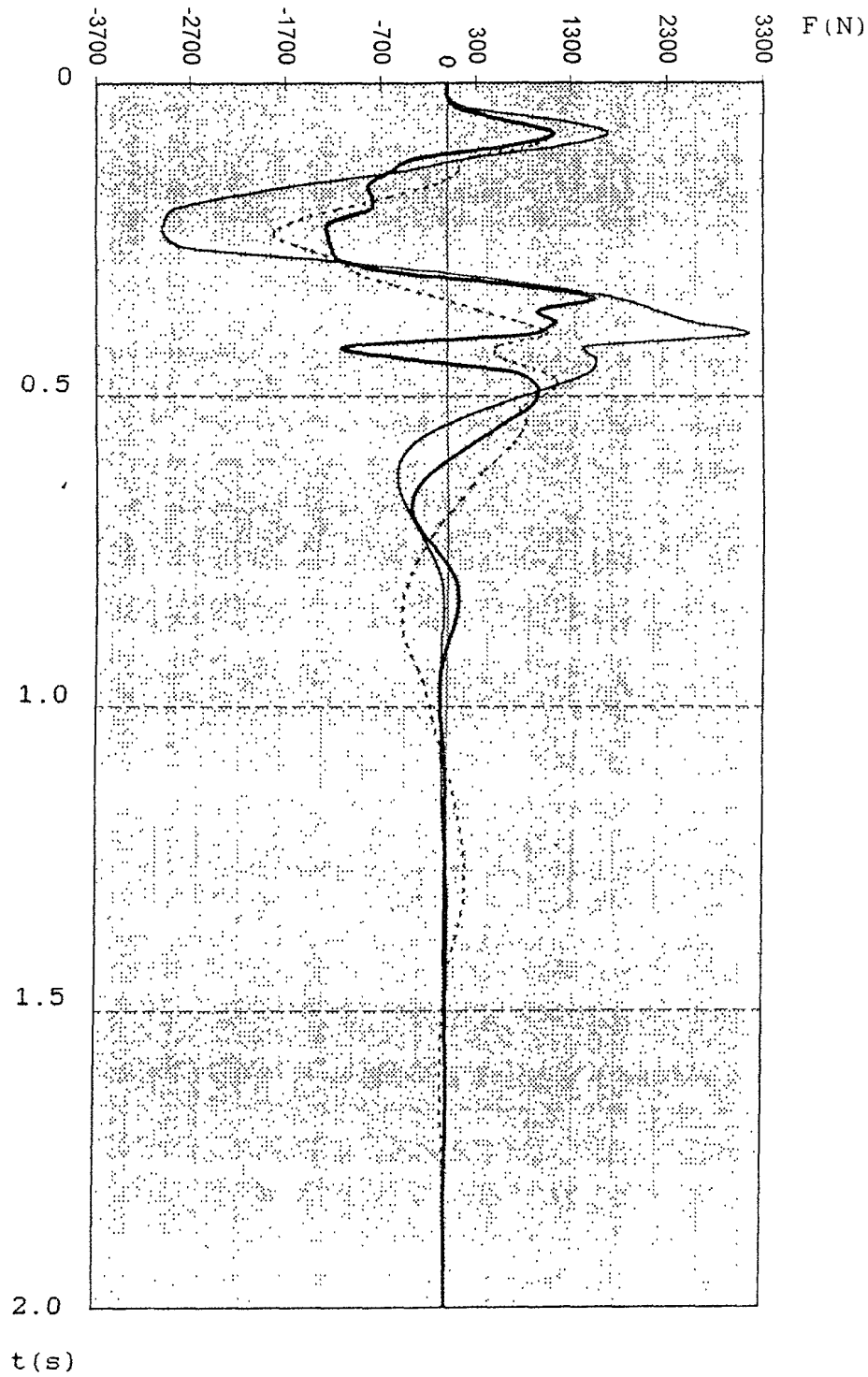


Fig. 32

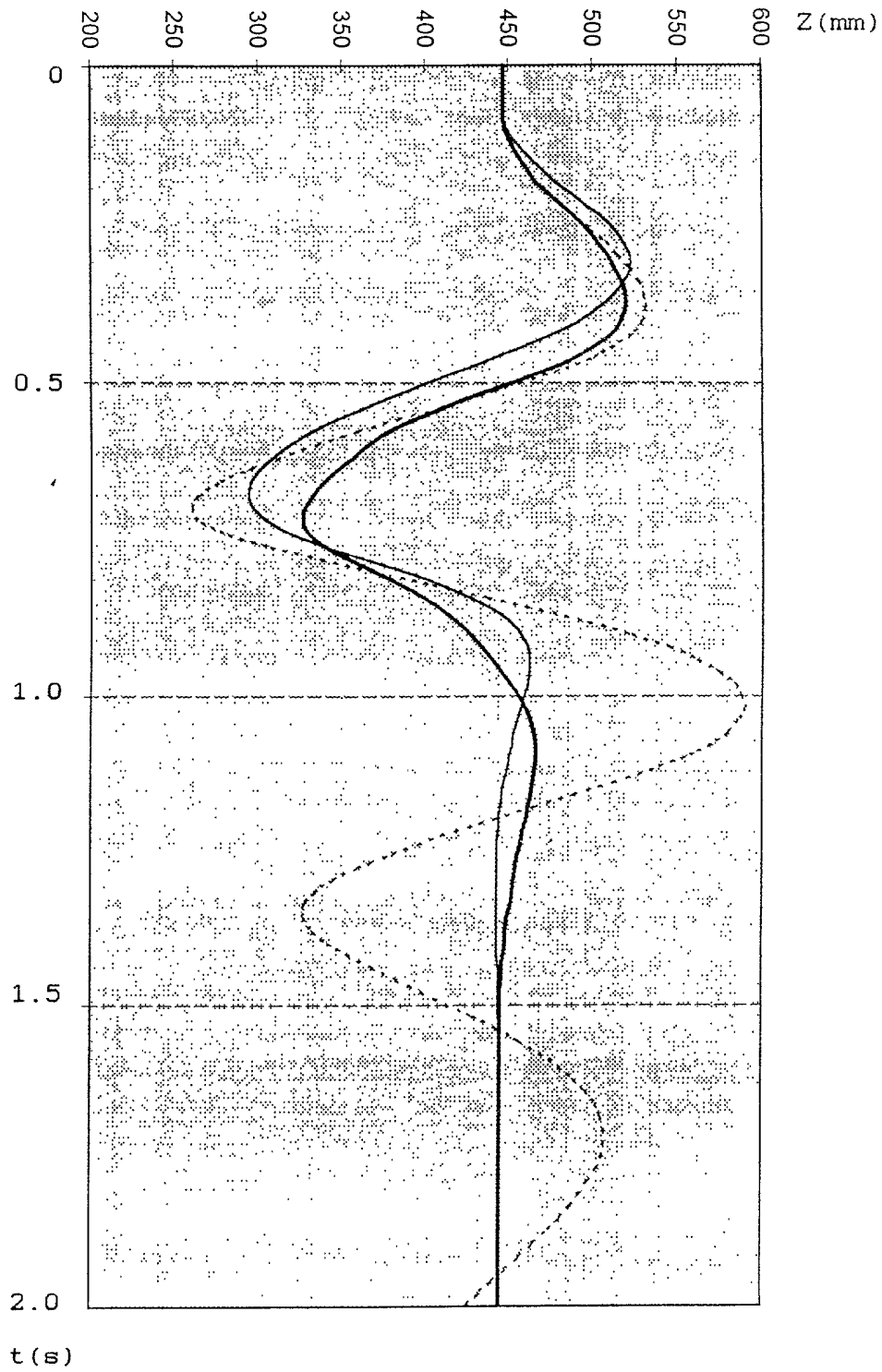


Fig. 33

U 013214-0

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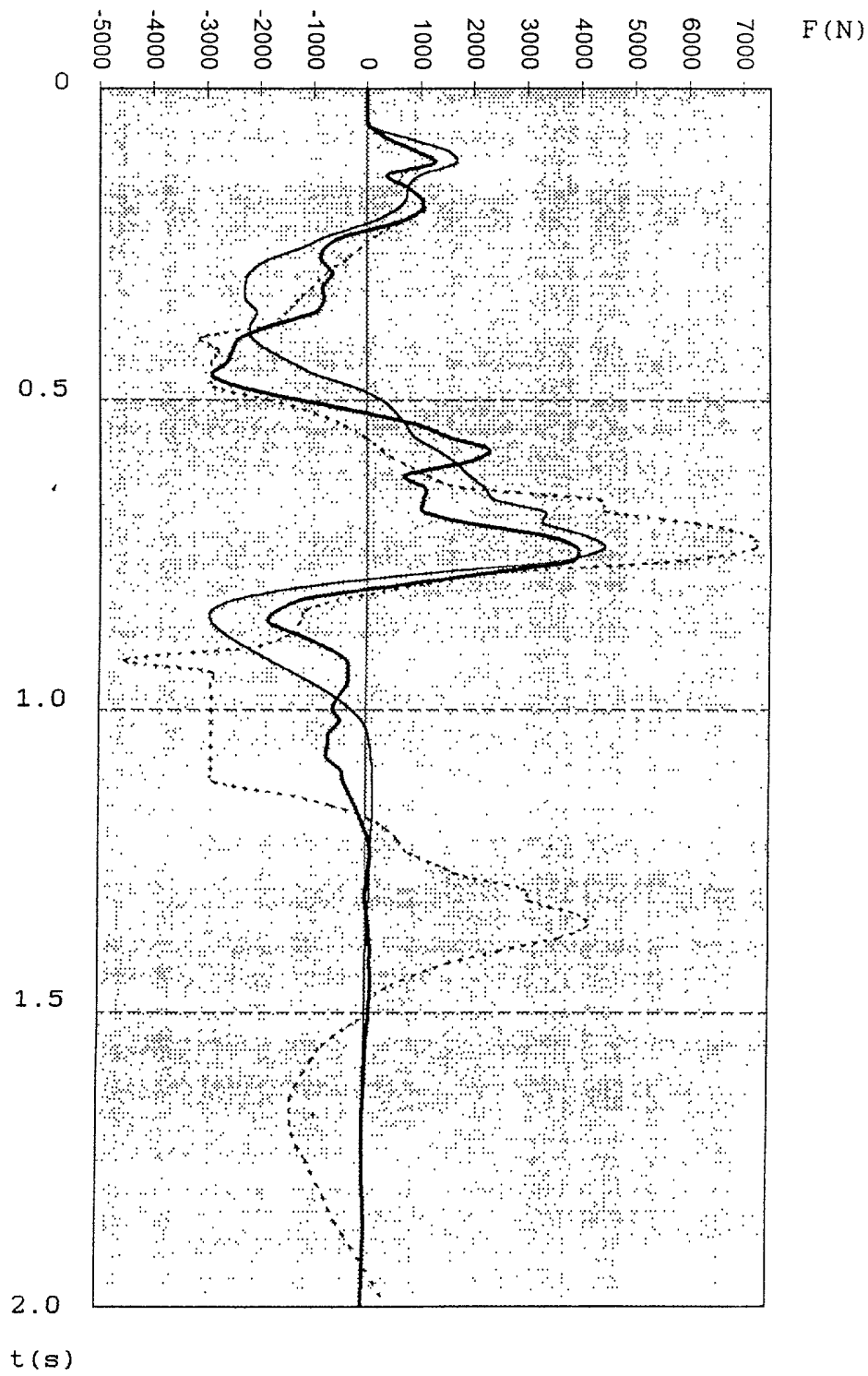


Fig. 34

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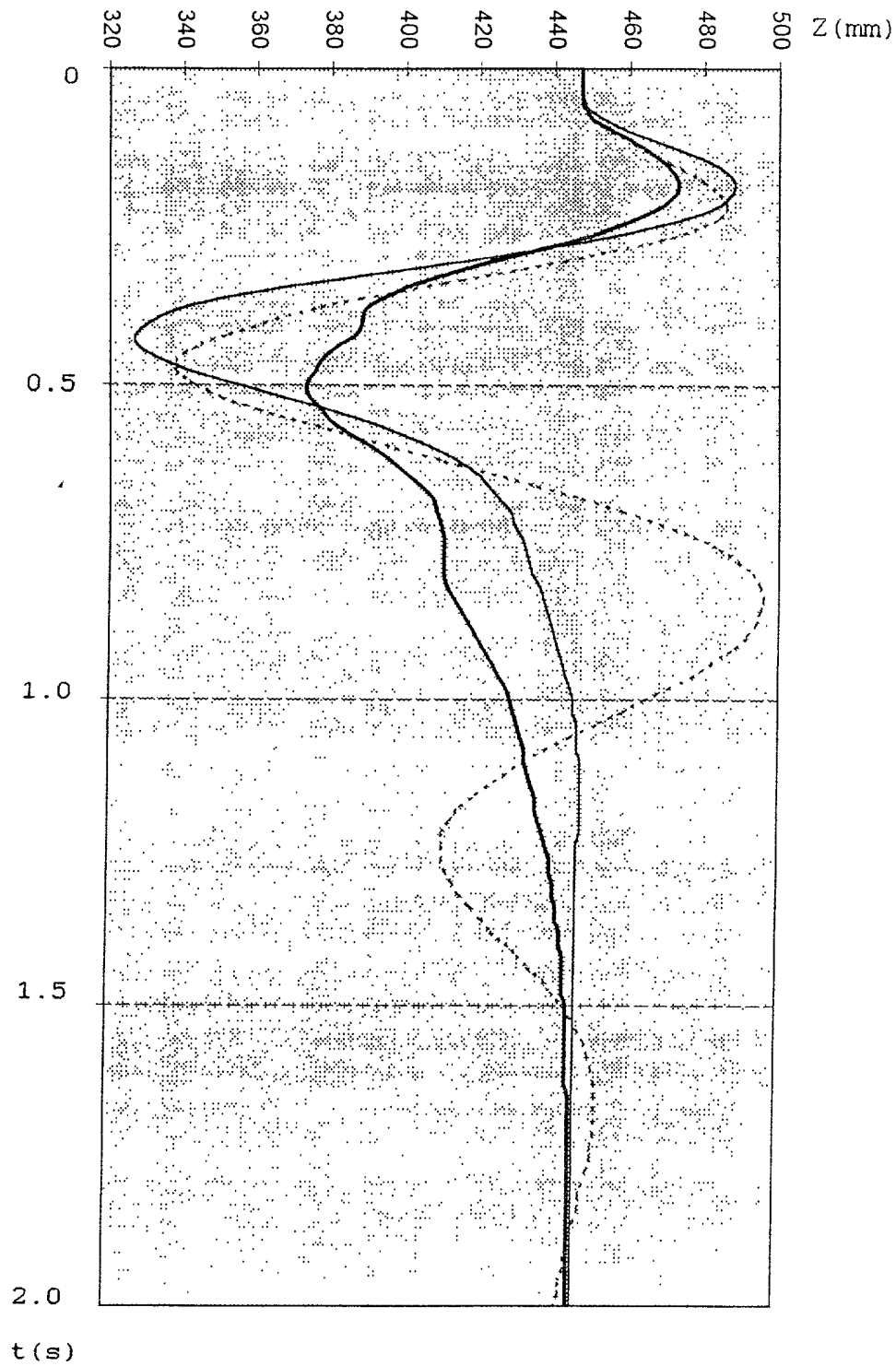


Fig. 35



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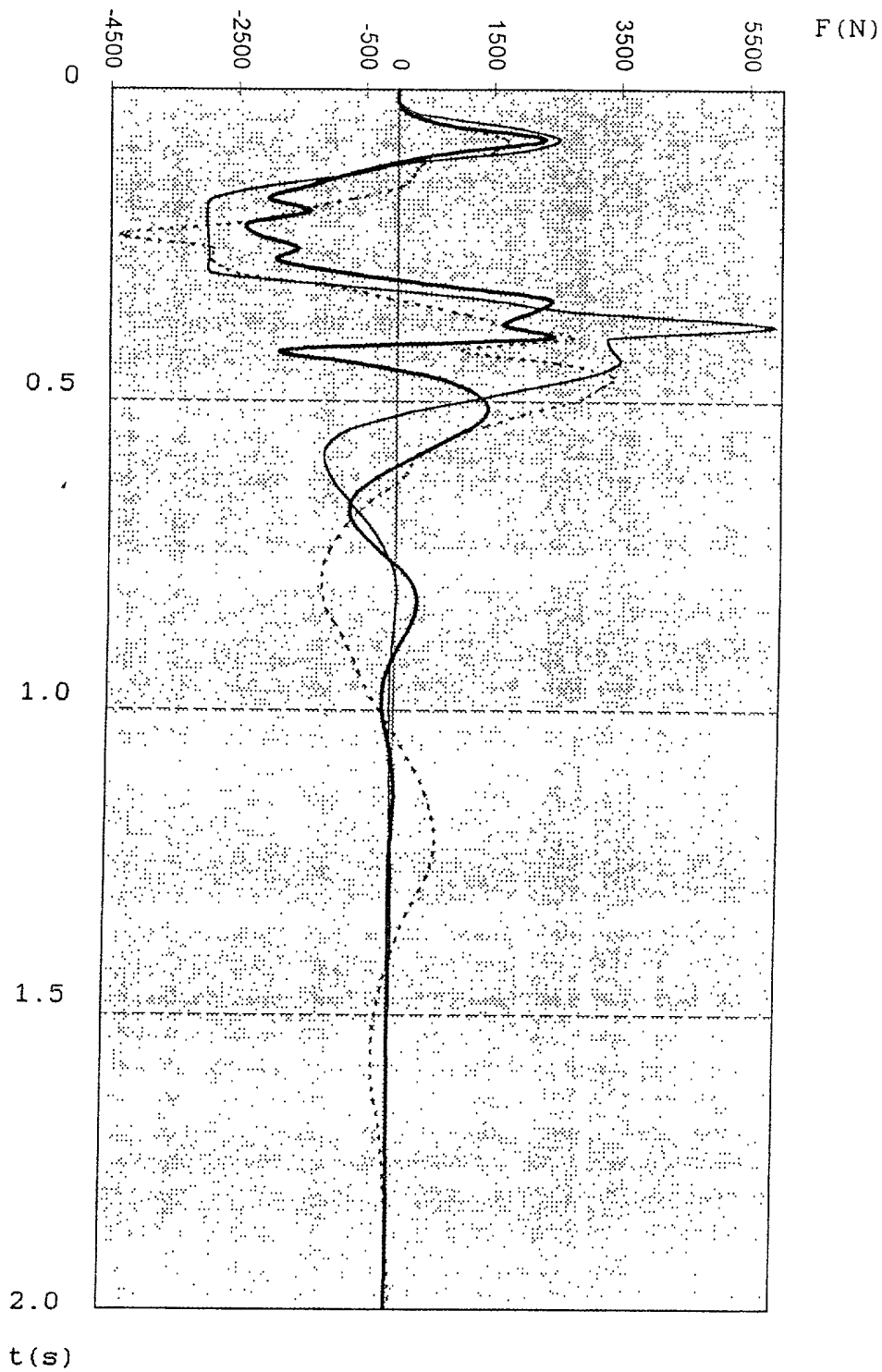


Fig. 36

---

**COMBINED DECLARATION AND POWER OF ATTORNEY**

---

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL,  
CONTINUATION, OR C-I-P)

---

As a below named inventor, I hereby declare that:

**TYPE OF DECLARATION**

This declaration is of the following type:

*(check one applicable item below)*

- ☐ original.  
☐ design.

**NOTE:** *With the exception of a supplemental oath or declaration submitted in a reissue, a supplemental oath or declaration is not treated as an amendment under 37 CFR 1.312 (Amendments after allowance). M.P.E.P. Section 714.16, 7<sup>th</sup> Ed.*

- ☐ supplemental.

**NOTE:** *If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.*

- ☒ national stage of PCT.

**NOTE:** *If one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR C-I-P.*

**NOTE:** *See 37 C.F.R. Section 1.63(d) (continued prosecution application) for use of a prior nonprovisional application declaration in the continuation or divisional application being filed on behalf of the same or fewer of the inventors named in the prior application.*

- ☐ divisional.  
☐ continuation.

**NOTE:** *Where an application discloses and claims subject matter not disclosed in the prior application, or a continuation or divisional application names an inventor not named in the prior application, a continuation-in-part application must be filed under 37 C.F.R. Section 1.53(b) (application filing requirements-nonprovisional application).*

- ☐ continuation-in-part (C-I-P).

**INVENTORSHIP IDENTIFICATION**

**WARNING:** *If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.*

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor *(if only one name is listed below)* or an original, first and joint inventor *(if plural names are listed below)* of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

(Declaration and Power of Attorney--page 1 of 8) 1-1

EXPRESS MAIL LABEL  
NO.: EL 728210618 US

## TITLE OF INVENTION

METHOD AND DEVICE (VARIANTS) FOR ADJUSTING THE  
RESISTANCE FORCE OF A LIQUID DAMPER

## SPECIFICATION IDENTIFICATION

The specification of which:

(complete (a), (b), or (c))

(a) ☒ is attached hereto.

**NOTE:** "The following combinations of information supplied in an oath or declaration filed on the application filing date with a specification are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 C.F.R. Section 1.63:

"(1) name of inventor(s), and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration on filing;

"(2) name of inventor(s), and attorney docket number which was on the specification as filed; or

"(3) name of inventor(s), and title which was on the specification as filed."

Notice of July 13, 1995 (1177 O.G. 60).

(b) ☐ was filed on \_\_\_\_\_, ☐ as Application No. \_\_\_\_\_  
☐ and was amended on \_\_\_\_\_ (if applicable).

**NOTE:** Amendments filed after the original papers are deposited with the PTO that contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 C.F.R. Section 1.67.

**NOTE:** "The following combinations of information supplied in an oath or declaration filed after the filing date are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 C.F.R. Section 1.63:

- (A) application number (consisting of the series code and the serial number, e.g., 08/123,456);
- (B) serial number and filing date;
- (C) attorney docket number which was on the specification as filed;
- (D) title which was on the specification as filed and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration;
- or
- (E) title which was on the specification as filed and accompanied by a cover letter accurately identifying the application for which it was intended by either the application number (consisting of the series code and the serial number, e.g., 08/123,456), or serial number and filing date. Absent any statement(s) to the contrary, it will be presumed that the application filed in the PTO is the application which the inventor(s) executed by signing the oath or declaration.

M.P.E.P. Section 601.01(a), 7th ed.

- (c) ☒ was described and claimed in PCT International Application No. RU98/00420 filed on 17.12.98 and as amended under PCT Article 19 on \_\_\_\_\_ (if any).

**SUPPLEMENTAL DECLARATION (37 C.F.R. Section 1.67(b))**

*(complete the following where a supplemental declaration is being submitted)*

☐ I hereby declare that the subject matter of the

☐ attached amendment

☐ amendment filed on \_\_\_\_\_.

was part of my/our invention and was invented before the filing date of the original application, above identified, for such invention.

**ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR**

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, Section 1.56,

*(also check the following items, if desired)*

☐ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and

☐ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 C.F.R. Section 1.98.

**PRIORITY CLAIM (35 U.S.C. Section 119(a)-(d))**

**NOTE:** "The claim to priority need be in no special form and may be made by the attorney or agent if the foreign application is referred to in the oath or declaration as required by Section 1.63. The claim for priority and the certified copy of the foreign application specified in 35 U.S.C. Section 119(b) must be filed in the case of an interference (Section 1.630), when necessary to overcome the date of a reference relied upon by the examiner, when specifically required by the examiner, and in all other situations, before the patent is granted. If the claim for priority or the certified copy of the foreign application is filed after the date the issue fee is paid, it must be accompanied by a petition requesting entry and by the fee set forth in Section 1.17(i). If the certified copy is not in the English language, a translation need not be filed except in the case of interference; or when necessary to overcome the date of a reference relied upon by the examiner; or when specifically required by the examiner, in which event an English language translation must be filed together with a statement that the translation of the certified copy is accurate." 37 C.F.R. Section 1.55(a).

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

- (d) ☐ no such applications have been filed. .  
(e) ☒ such applications have been filed as follows.

**NOTE:** Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.

**PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION  
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. SECTION 119(a)-(d)**

COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING DAY, MONTH, YEAR	PRIORITY CLAIMED UNDER 35 USC 119
RU	98114638	27/07/1998	<del>X</del> ]YES [ ]NO
			[ ]YES [ ]NO
			[ ]YES [ ]NO
			[ ]YES [ ]NO
			[ ]YES [ ]NO

**CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)**  
(35 U.S.C. Section 119(e))

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

**PROVISIONAL APPLICATION NUMBER**

**FILING DATE**

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**CLAIM FOR BENEFIT OF EARLIER U.S./PCT APPLICATION(S)**  
**UNDER 35 U.S.C. SECTION 120**

[ ] The claim for the benefit of any such applications are set forth in the attached ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR CONTINUATION-IN-PART (C-I-P) APPLICATION.

**ALL FOREIGN APPLICATION(S), IF ANY, FILED MORE THAN 12 MONTHS**  
**(6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION**

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**NOTE:** If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. Section 120.

**POWER OF ATTORNEY**

I hereby appoint the following practitioner(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

(list name and registration number)

JOSEPH H. HANDELMAN, 26179

RICHARD P. BERG, 28145

JOHN RICHARDS, 31053

JULIAN H. COHEN, 20302

RICHARD J. STREIT, 25765

WILLIAM R. EVANS, 25858

PETER D. GALLOWAY, 27885

JANET I. CORD, 33778

IAN C. BAILLIE, 24090

CLIFFORD J. MASS, 30086

THOMAS F. PETERSON, 24790

CYNTHIA R. MILLER, 34678

(Check the following item, if applicable)

(Declaration and Power of Attorney--page 5 of 8) 1-1

EXPRESS MAIL LABEL  
NO.: EL 728210618 US

- ☐ I hereby appoint the practitioner(s) associated with the Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.
- ☐ Attached, as part of this declaration and power of attorney, is the authorization of the above-named practitioner(s) to accept and follow instructions from my representative(s).

**NOTE:** "Special care should be taken in continuation or divisional applications to ensure that any change of correspondence address in a prior application is reflected in the continuation or divisional application. For example, where a copy of the oath or declaration from the prior application is submitted for a continuation or divisional application filed under 37 CFR 1.53(b) and the copy of the oath or declaration from the prior application designates an old correspondence address, the Office may not recognize, in the continuation or divisional application, the change of correspondence address made during the prosecution of the prior application. Applicant is required to identify the change of correspondence address in the continuation or divisional application to ensure that communications from the Office are mailed to the current correspondence address. 37 CFR 1.63(d)(4)." Section 601.03, M.P.E.P., 7th Ed.

SEND CORRESPONDENCE TO

DIRECT TELEPHONE CALLS TO:  
(Name and telephone number)

Ladas & Parry  
26 West 61<sup>st</sup> Street  
New York, N.Y. 10023

(complete the following if applicable)

Since this filing is a ☐ continuation ☐ divisional there is attached hereto a Change of Correspondence Address so that there will be no question as to where the PTO should direct all correspondence.

#### DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## SIGNATURE(S)

**NOTE:** Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other document.

**NOTE:** Each inventor must be identified by full name, including the family name, and at least one given name without abbreviation together with any other given name or initial, and by his/her residence, post office address and country of citizenship. 37 C.F.R. Section 1.63(a)(3).

**NOTE:** Inventors may execute separate declarations/oaths provided each declaration/oath sets forth all the inventors. Section 1.63(a)(3) requires that a declaration/oath, inter alia, identify each inventor and prohibits the execution of separate declarations/oaths which each sets forth only the name of the executing inventor. 62 Fed. Reg. 53,131, 53,142, October 10, 1997,

### Full name of sole or first inventor

EVGENY IVANOVICH TERNOVSKY  
(Given Name) (Middle Initial or Name) Family (Or Last Name)

Inventor's signature Евгений Иванович Терновский

Date January 12, 2001 Country of Citizenship Russian Federation

Residence Russian Federation, Ozersk RUX

Post Office Address Russian Federation, Ozersk, Chelyabinskaya  
oblast, prospekt Karla Marxa, 24, kv.41

### Full name of second joint inventor, if any

VLADIMIR GRIGORIEVICH TUROV  
(Given Name) (Middle Initial or Name) Family (Or Last Name)

Inventor's signature Владимир Григорьевич Туров

Date January 12, 2001 Country of Citizenship Russian Federation

Residence Russian Federation, Ozersk RUX

Post Office Address Russian Federation, Ozersk, Chelyabinskaya  
oblast, mikroraion Zaozerny, 6, korpus 3, kv.100

### Full name of third joint inventor, if any

\_\_\_\_\_  
(Given Name) (Middle Initial or Name) Family (Or Last Name)

Inventor's signature \_\_\_\_\_

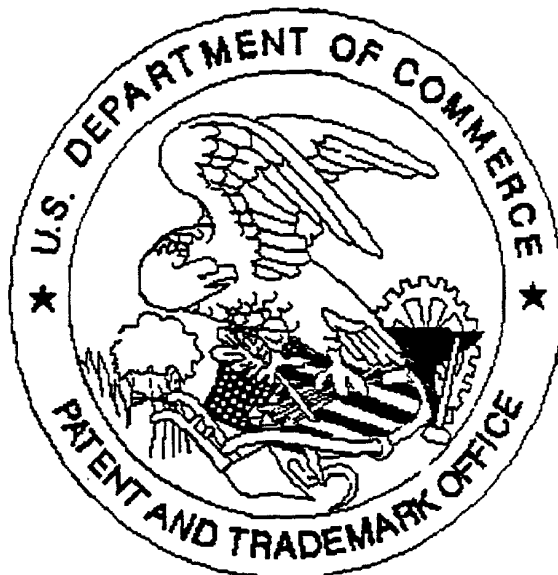
Date \_\_\_\_\_ Country of Citizenship \_\_\_\_\_

Residence \_\_\_\_\_

Post Office Address \_\_\_\_\_



United States Patent & Trademark Office  
Office of Initial Patent Examination -- Scanning Division



Application deficiencies found during scanning:

☒ Page(s) 8 of Declaration were not present  
for scanning. (Document title)

☐ Page(s) \_\_\_\_\_ of \_\_\_\_\_ were not present  
for scanning. (Document title)

☐ *Scanned copy is best available.*